Chapter 28. Flood Management

Flood management consists of two primary activities:

- Managing floodwater (keeping floodwater away from people and property assets)
- Managing floodplains (keeping people and assets out of the path of floodwater, as well as protecting and restoring natural systems and habitats, where possible).

Historical flood management actions in California typically have focused on delivering site-specific solutions providing one or two primary benefits. This involved the physical modification of stream channels, dam and surface impoundments, levees, and/or other structures. Altering or confining natural watercourses reduces the intensity or duration of flooding and helps avoid damage to lives and property. Traditional flood management can successfully reduce flood risk to people and property, but it also can affect the natural functions of floodplains. In California, flood management is administered by an assortment of agencies and institutions with overlapping and, in some cases, conflicting mandates. Costs for operations and maintenance (O&M) for existing infrastructure have increased as agencies are forced to navigate through innumerable and sometimes contradicting regulations. Traditional planning processes rely on project proponents that typically have a narrowly focused mission (e.g., public safety or water supply) and a specific geographic footprint. Hence, such projects miss the opportunity to provide a broader suite of benefits that include systemwide considerations. A broader-based integrated water management (IWM) approach for flood management throughout California can provide multiple benefits. Many agencies are progressing toward this integrated planning approach, but much more needs to be accomplished.

IWM changes the implementation approach based on the understanding that water resources (including flood management) are an integral component for sustainable ecosystems, economic growth, water supply reliability, public health and safety, and other interrelated elements. Additionally, IWM acknowledges that a broader range of stakeholders might have interests and perspectives that could positively influence planning outcomes. By employing an IWM approach, interagency coordination and watershed-based planning are emphasized, and multiple agencies can help foster informed decisions for flood management. IWM considers both structural and nonstructural solutions (management actions) within the context of natural, engineered, environmental, economic, and political systems. The future of flood management lies in employing IWM as an overall flood management strategy by providing the framework for long-term economic stability, public safety, and enhancement of environmental stewardship. Successful implementation of an IWM approach to flood management should include the following:

- Agency Alignment – Facilitate and direct agency alignment to expedite priority projects and encourage IWM
- Reliable Funding – Establish multiple approaches to achieve reliable funding while incentivizing IWM
- Flood Risk Awareness – Improve awareness about flood risks to reduce the impacts of flooding, and improve the functioning of natural systems
- Flood Readiness – Support flood emergency preparedness, response, and recovery programs to reduce risks to lives and property

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- Land Use Planning – Encourage land use planning practices that reduce impacts to lives and property while protecting existing ecosystems
- Risk Assessments – Conduct regional flood threat assessments to prioritize actions that reduce risk while identifying opportunities to restore or maintain existing natural systems
- Regional Planning – Use regional planning to establish priority projects with an IWM approach

Flood Management in California

Background

Flood risk in California is real. Today, one in five Californians lives in a floodplain, and most Californians rely on infrastructure (goods and services) that are at risk to flooding. Conservative estimates indicate that more than 7 million people and $580 billion in assets (crops, buildings, and public infrastructure) are exposed to the hazards of flooding in California. Population growth, development in flood-prone areas, and climate changes will lead to an even greater number of people and property exposed to flood hazards in the future.

Flooding occurs in all regions of the state at different times of the year and in different forms—from tsunamis in coastal areas (North Coast Region) to alluvial fan flooding in the deserts (South Lahontan Region), and from fast-moving flash floods in the South Coast Region to slow-rise deep flooding in the Central Valley. Sometimes the source of flooding is the Pacific Ocean or large bays, such as the flooding seen when the city of Pacifica experienced damages due to coastal flooding and when Crescent City was the landfall of several tsunamis. Flooding varies according to the complexities and diversity of the physical features of the landscape, weather, and climate, and human manipulations of the landscape. California has regional demographic differences, due in part to historical settlement patterns, land use regulations, and economic drivers, all of which have an impact on susceptibility to effects of flooding. Flood warning times vary across the state with longer lead times for slow-rise flooding and often with little or no lead time for flash flooding. Figure 1 shows the flooding types in California, as well as the areas of the state where each type is apt to occur.

Exposure to flood hazard is distributed throughout the state, with virtually all regions having some level of exposure to flooding, as illustrated in Figure 2. The significance of this exposure considers the following facts:

- More than 3.3 million people in the South Coast Hydrologic Region and more than 1 million people in the San Francisco Bay Hydrologic Region live in floodplains.
- The South Coast, San Francisco Bay, and Sacramento River hydrologic regions have more than $430 billion in structures exposed, including essential, high-potential loss, and lifeline facilities.
- The Sacramento, Central Valley, and Tulare Lake hydrologic regions have more than $5.9 billion in agricultural crops exposed to flooding.
- [Bullet to be added on results of environmental resources analysis, which is not completed]

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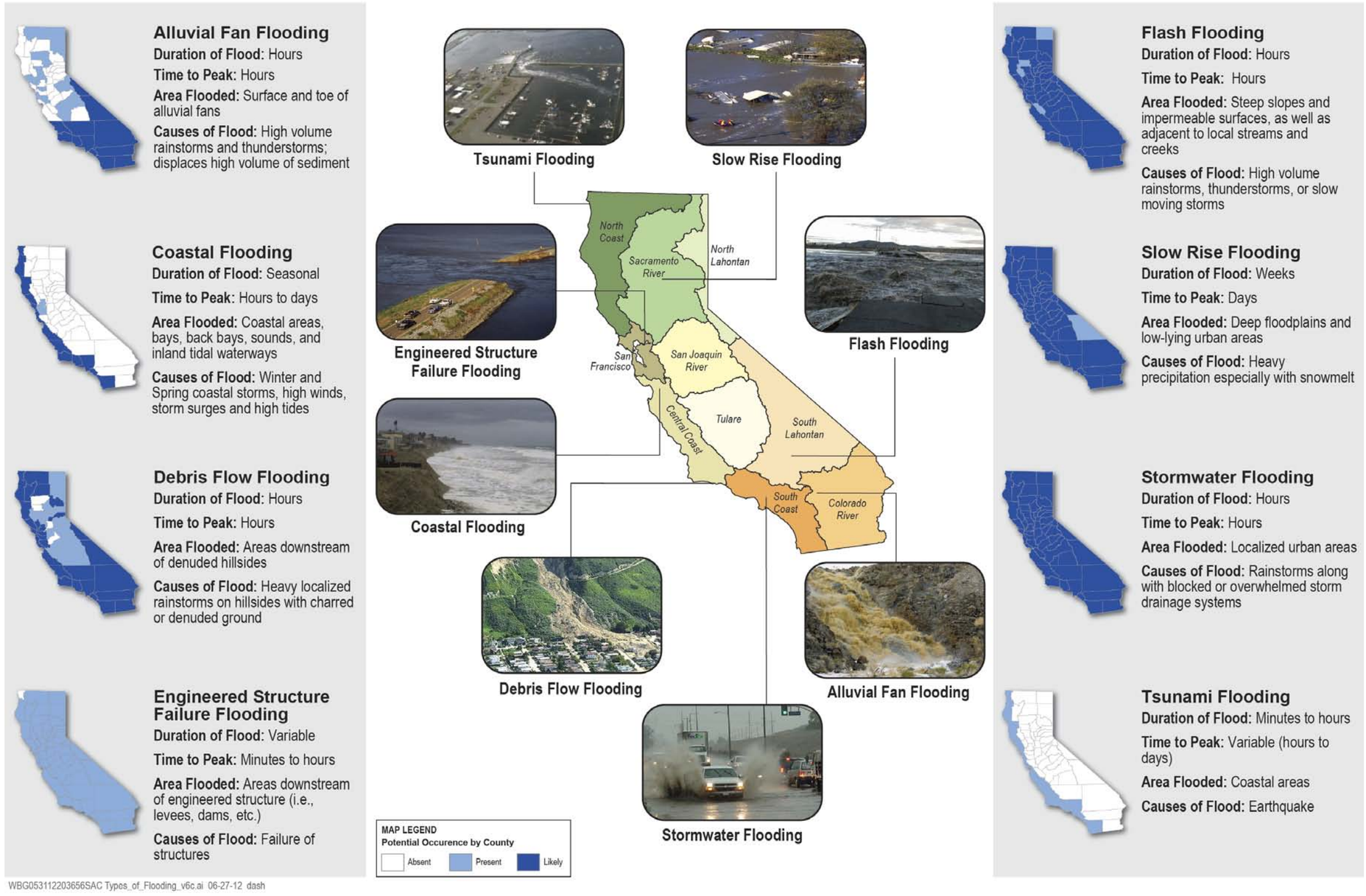

Figure 1. Flood Types in California

This extent of exposure is significant because it can result in tragic loss of life and can have a devastating impact on the State's economy and environmental resources. When floods occur in California:

- Critical infrastructure is damaged and could be out of service for long periods. At risk are interstate highways, airports, ports and transit facilities; gas and electric utilities; water supply and wastewater facilities; and military installations.
- Necessary facilities, such as hospitals, police and fire stations, schools, and other vital services, become isolated or are closed.
- Agricultural lands are taken out of production, which could have a significant impact on national food supplies.
- Levee failures in the Sacramento-San Joaquin Delta could endanger a portion of the water supply for 60 percent of California residents, as well as a portion of the State's vital agricultural industry.
- Critical habitat and environmental resources could be damaged or lost due to flooding. While the potential for habitat loss exists, particularly during severe floods, at the same time flooding is part of the natural cycle that provides the opportunity to renew and revitalize environmental resources.

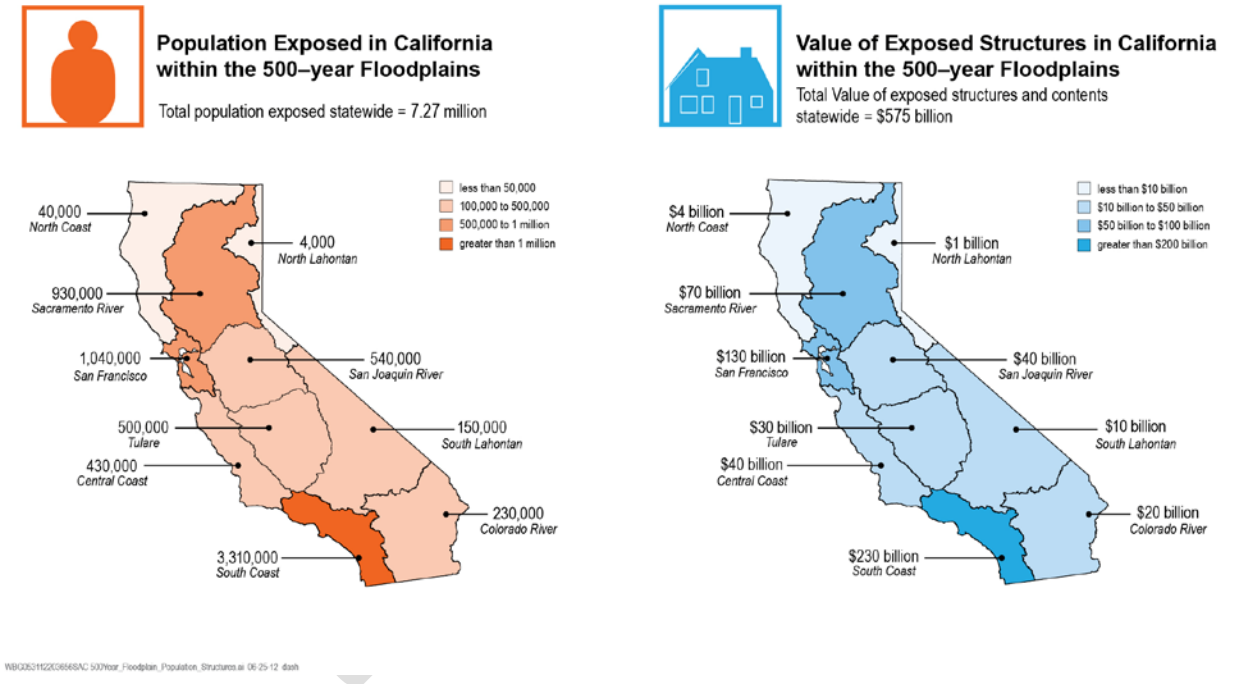

Figure 2. Exposure to Flooding in California

To address the high level of exposure to flooding in California, a complex network of agencies and infrastructure has been developed. Hundreds of local agencies have responsibility for some aspect of flood management, including planning, administering, financing, and maintaining flood management facilities and emergency response programs. Due to the many agencies, jurisdictions, and governance structures, coordinating flood management planning and operations is a challenge. Historically, these agencies have developed infrastructure to reduce or avoid damage from location-specific flooding using structural approaches, including the following:

- More than 11,380 miles of levees
- 1,738 dams
- 612 debris basins
- 36 major reservoirs
- A myriad of other facilities

This flood management infrastructure has prevented billions of dollars of damage and saved numerous lives; however, this infrastructure has sometimes resulted in changes to floodplains and other natural ecosystems that have resulted in loss or degradation of habitat.

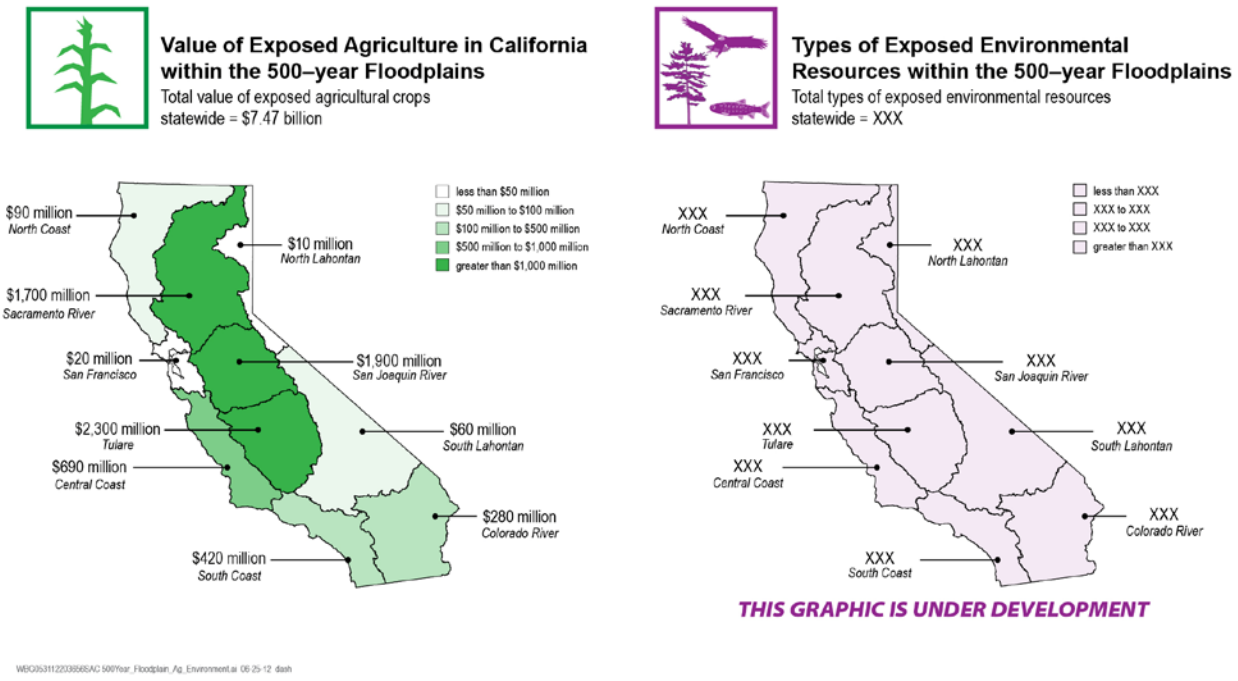

Figure 2. Exposure to Flooding in California (continued)

Description

Historically, flood management has focused on location-specific, single-purpose formulation of projects. The traditional approach to flood management concentrated primarily on mitigating negative impacts of floods, relying on flood infrastructure to alter or confine natural watercourses, reduce the chance of flooding, and avoid damage to lives and property. This approach looked at floodwaters primarily as a potential risk to be mitigated, instead of as a natural resource that could provide multiple collective benefits. It has also limited the potential beneficial functions of floodplains and caused other unintended consequences, such as disconnected ecosystem functions and redirection of flood risks to upstream or downstream areas. As societal values have evolved and appreciation for prudent floodplain management has grown, the concept of flood management has shifted from this traditional location-specific, single-purpose approach to a holistic one that views flood management as a part of integrated water management. Today, a majority of flood management agencies have mission statements that include IWM ideals and over one-fourth of proposed new flood-related projects use an IWM approach. This shift has been driven by a need to gain stakeholder support, maximize existing funding sources, meet environmental needs, and maximize public safety.

Integrated water management reinforces the interrelation of different water management components—such as water supply, flood management, water quality, and environmental stewardship—with the understanding that changes in the management of one component will affect the others. The application of integrated flood management extends the range of strategies that could be employed to include those that might be focused on other water management issues. This combination provides more flexibility and resiliency for both flood management, water supply, and environmental management and conservation to adapt to a changing climate.

Six key elements help illustrate how flood management can be implemented as part of an IWM approach:

- **Systemwide Flood Management at a Watershed Scale:** Recognizes the importance of evaluating opportunities and potential impacts of flood management from a systemwide watershed perspective, and coordinating across geographic and agency boundaries to achieve sustainable outcomes.
- **Leveraging Natural Watershed Features:** Leverages the potential of natural watershed features to reduce the intensity or duration of flooding. Natural watershed features include undeveloped floodplains that can store and slowly release floodwaters; wetlands that act as sponges, soaking up floodwaters, filtering runoff, and providing opportunities for infiltration to groundwater; healthy forests, meadows, and other open spaces that can slow runoff during smaller flood events, reducing peak flows, mudslides, and sediment loads in streams.
- **Integrating Flood Management and Land Use:** Integrates land use planning in the process because of its potential impacts on flood magnitudes and flood risks.
- **Promoting Multiple Benefits:** Provides opportunities to reduce flooding while providing broader benefits. Managed floodwaters and stormwater can be a resource for water supply augmentation, pollution prevention and source control, as well as ecosystem restoration and recreation. Conversely, flood management benefits could be derived from implementing IWM strategies.
- **Implementing Multi-Hazard Management:** Takes into consideration flooding risks induced by other hazards such as landslides, wildfires, and earthquakes. Landslides and wildfires can directly contribute to debris-flow flooding. Earthquakes can lead to tsunami flooding or contribute to dam or levee failure. These hazards call for a multi-hazard approach to emergency

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planning and management that incorporates flood management as part of a wider risk management system.

- **Adopting a "Best Mix" of Structural and Nonstructural Approaches:** Compares all available structural and nonstructural approaches and selects a strategy or a combination of strategies that is most appropriate for management objectives. Structural approaches modify flood patterns and rely primarily on constructed components. There are a variety of nonstructural approaches, including those that reduce or eliminate susceptibility to flooding by preserving or increasing the flood-carrying capacity of floodways (California Water Code Section 79068[a]).

Many local and regional agencies have been implementing multi-objective, integrated water management programs and projects that provide multiple benefits in flood and watershed management, ecosystem restoration, water supply and water quality improvement, and recreation enhancement. Two examples of IWM projects developed to address flood management issues are provided in Exhibits 28-1 and 28-2.

Exhibit 28-1. Lower Carmel River Floodplain Restoration and Flood Control Project

The Lower Carmel River Floodplain Restoration and Flood Control Project provides an example of how multiple flood management approaches can be combined to address a variety of flooding issues in a single project. Human activities and infrastructure—water diversions, gravel mining, agricultural and urban development, roads, levees, bridges, and buildings—have altered the Lower Carmel River by isolating the floodplain from the river channel. This has reduced floodplain acreage and redirected flood flows to cause repetitive flooding problems, significantly compromised riparian and wetland habitat, increased sedimentation at the river mouth, and increased erosion in adjacent scenic coastal roadways during flood events. The Big Sur Land Trust, Monterey County Water Resources Agency, Monterey County Public Works Department, and California Department of Parks and Recreation are planning and implementing a variety of structural and nonstructural flood management approaches to address flooding on the Lower Carmel River, including the following:

- Modifying placement or size of existing levees and floodwalls, and adding new levees or floodwalls to improve flood protection
- Improving hydrologic functions by reconnecting floodplains through regrading lands; modifying, setting back or removing nonstructural levees; restoring channels and constructing bypasses; revegetating with native species; and reestablishing riparian and wetland habitat in the floodplain along with off-channel wetland habitat
- Integrating storage and filtration basins into restored floodplains to increase flood flow retention, promote sediment and nutrient removal, and increase groundwater recharge

Exhibit 28-2. Upper San Diego River Improvement Project

The Upper San Diego River Project led by Lakeside's River Park Conservancy provides an example of how a flood management project can provide multiple benefits. Sand mining has dominated the community of Lakeside, located along the upper San Diego River, since the 1930s. Two sand mining ponds created deep, open water in the river channel, which traps sediment and decreases channel capacity during a flood. Many of the natural functions of the river, including habitat, water quality, and recharge, have been lost in the process of channelizing portions of the river. The river has also lost its place as a source of recreation in the community. The focus of the Upper San Diego River Improvement Project was to fill the two existing ponds and restore the natural functions of the San Diego River Corridor on a 100-acre site formerly used as a sand and gravel mine. The project has achieved multiple benefits, including the following:

- **Flood:** Widened and restored a channel to increase conveyance capacity, reduced flood levels, improved sediment balance, protected downstream bridges and water pipelines, and prevented urban development in a floodplain that is subject to development pressure.
- **Environmental:** Created, restored, and enhanced more than 90 acres of wetland habitat for threatened and endangered species, and improved downstream water quality with the creation of constructed wetlands and a bioswale.
- **Water supply:** A constructed wetlands treats urban runoff and allows it to recharge into the aquifer, increasing groundwater storage, which supports municipal wells important to the local community.
- **Recreation:** Added approximately 1 mile of publicly accessible new river trails along the banks of the newly restored river channel. The project also included camping areas, trails, and a boardwalk in the pond with access for the disabled and interpretive educational information.
- **Transportation:** In a win-win collaboration with the California Department of Transportation, 400,000 cubic yards of fill material from channel excavation was used to construct the extension of State Route 52 to Highway 67, providing cost savings for both agencies.

Management Actions

Management Actions are strategies, options, and best practices available to decision makers and flood managers to address flood-related issues. These actions can be integrated with other resource management strategies (e.g., water supply, water quality, ecosystem restoration, and recreation) to create multipurpose or IWM projects.

A management action is a specific structural or nonstructural strategy, action, or tactic that contributes to reaching goals and addressing problems. These actions range from policy or institutional changes to operational and physical changes to flood infrastructure. Management actions serve as a toolkit of potential actions that local, State, and Federal agencies can use to address different types of flood hazards (e.g., slow-rise, flash, debris-flow, alluvial fan, coastal, tsunami) and different aspects of flood risks (hazard, exposure, vulnerability). Such actions are not recommendations; rather, they serve as a suite of generic tools or planning features that can help tailor and improve a variety of specific projects or programs.

Management actions were identified and grouped into nine broad categories, including:

- **Floodplain conservation and restoration -** Floodplain conservation and restoration methods recognize that periodic flooding of undeveloped lands adjacent to rivers and streams is a natural function and could be preferred rather than restricting flood flows to the existing channel. Human activities (including flood infrastructure such as dams, levees, channel stabilization, and bank protection) have modified the natural process of floodplain inundation and disrupted sediment transport and deposition, which are important drivers in creating a diversity of floodplain and riparian habitat to support fish and wildlife. Restoring these natural processes, reducing the occurrence of invasive species, and increasing the quantity, quality, and connectivity of native floodplain habitat are key priorities of floodplain conservation and restoration.
- **Land use and floodplain management (e.g., floodproofing, easements/acquisitions, risk awareness, insurance)** - Land use planning and floodplain management generally refers to land use and nonstructural actions that reduce flood damages and losses. Land use policies, land acquisitions, and easements reduce the damages that flooding causes by limiting development in flood-prone areas while encouraging land uses that are compatible with floodplain functions. Building code amendments could require floodproofing measures in buildings to increase their resilience to flooding. Land use planning and floodplain management includes flood insurance to protect against flood losses, as well as outreach and education to educate the public about the risks of flooding.
- **Flood infrastructure (e.g., levees/floodwalls, bypasses, hydraulic structures, debris basins, storm surge barriers) -** A wide variety of flood infrastructure is used to address different types of flooding. Flood infrastructure generally seeks to alter or confine floodwaters to reduce the chance of flooding. Examples include levees, floodwalls, channels, bypasses, coastal armoring structures, shoreline stabilization, storm surge barriers, and debris mitigation structures.
- **Floodplain and reservoir storage and operations** – Floodplain and reservoir storage provides an opportunity to regulate flood flows by reducing the magnitude of the flood peaks in downstream channels. Reservoirs collect and store water behind a dam, and floodplain storage occurs when flows are diverted to adjacent off-stream areas. Improvements in storage operations seek to optimize the magnitude or timing of reservoir releases or through greater coordination of storage operations.
- **O&M** - Because many flood facilities that were constructed in the early to mid-twentieth century are near or have exceeded the end of their expected service lives, adequate maintenance is critical for these facilities to continue to function properly. Funding limitations have placed further strain on flood facilities by causing some maintenance to be deferred, which can greatly increase the risk of failure. Operations and maintenance activities can include inspection, vegetation management, sediment removal, management of encroachments and penetrations, repair or rehabilitation of structures, or erosion repairs.
- **Flood preparedness, response, and recovery** - Flood preparedness includes the development of plans and procedures for responding to a flood before the actual flood emergency, including preparing emergency response plans, training local response personnel, designing evacuation procedures, conducting exercises to assess readiness, and developing emergency response agreements that address issues of liability and responsibility. Emergency response is the aggregate of all actions taken by responsible parties at the time of a flood emergency, such as flood-fighting, flood warning, flood forecasts, and evacuation. Flood recovery includes programs and actions to recover from floods and includes restoring utility services and public facilities,

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repairing flood facilities, draining flooded areas, removing debris, and assisting individuals, businesses, and communities to protect lives and property.

- **Policy and regulations** - Policies and regulations could address many of the institutional issues affecting effective and efficient flood management. Such policy and regulatory actions include encouraging multi-jurisdictional and regional partnerships on flood planning, improving agency coordination, and clarifying flood management responsibilities for local, regional, State and federal agencies.
- **Permitting** - Numerous permits are required to conduct routine maintenance, restoration, physical improvements, and other activities. Developing proactive integrated regulatory compliance strategies could provide faster and better delivery of flood management projects. For example, regional and programmatic permitting methods could be used to collectively comply with permitting requirements for multiple projects over longer planning horizons, while also consolidating mitigation and conservation efforts into larger, more viable conservation areas.
- **Finance and revenue -** Finance and revenue actions seek to increase funding for flood management projects. This includes maximizing State and federal funding, developing new funding mechanisms, or creating shared strategic pooled-money accounts to pre-fund some flood management activities.

Table 28-1 displays a list of opportunities and challenges to integrating flood management actions for these nine categories. They are intended to broadly illustrate the flood management action category as a whole, rather than list individual actions within the category. More detailed information for individual management actions is included in Appendix A.

Connections to Other Resource Management Strategies

Many other resource management strategies that are in the Water Plan Update 2013 share a connection with the flood management actions. These include:

- **Ecosystem Restoration:** Floodplain environments are dynamic in nature and are highly productive biological communities, given their proximity to water and the presence of fertile soils and nutrients. Native riparian and aquatic animal and plant communities of California are adapted to conditions of seasonal flooding. Many of the greatest opportunities for ecosystem restoration require incorporation of habitat into the flood management system. The principal opportunities for improvement in both flood management and ecosystem restoration occupy the same spatial footprint and are affected by the same physical processes that distribute water and sediment in rivers and across floodplains. Integrating ecosystem conservation and restoration into flood n projects are essential to sustainable flood management. Flood management projects that protect and restore ecosystems will likely cause increased effectiveness, sustainability, and public support.
- **Sediment Management:** Floods have a major role in transporting and depositing unconsolidated sediment onto floodplains. Erosion and deposition help to determine the shape of the floodplain, the depth and composition of soils, and the type and density of vegetation. Disruption of natural sediment transport dynamics can cause failure of adjacent levees because of related increased erosion, or it can reduce the flood carrying capacity of natural channels because of increased sedimentation. Sediment is a major component in alluvial fan and debris-flow flooding as well.

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Table 28-1. Flood Management Action Categories

Flood Management Action Category	Specific Management Actions	Potential Integration Opportunities	Potential Integration Challenges
Floodplain Conservation and Restoration	• Manage runoff through watershed management • Develop hazardous waste and materials management protocols • Operate reservoirs with flood reservation space to more closely approximate natural flow regimes • Reduce the incidence of invasive species • Remove barriers to fish passage • Set back levees to connect rivers to floodplains • Encourage natural physical geomorphic processes • Improve the quality, quantity, and connectivity of wetland, riparian, woodland, grassland, and other native habitat communities	• Improved ecosystem functions and habitats • Invasive species management • Potential to enhance recreation and open space • Possible water supply benefits by increasing groundwater infiltration	• Complex institutional, jurisdictional, and funding issues
Land Use and Floodplain Management (*floodproofing, easements/ acquisitions, risk awareness, insurance*)	• Reduce flood damages through acquisitions, easements, and private conservation programs • Manage municipal stormwater to provide regional or systemwide flood benefits • Coordinate and streamline floodplain mapping • Develop mandatory flood insurance programs that are more consistent with the area's risk of flooding • Develop a State program and framework to reduce or eliminate subsidies for repetitive loss properties in floodprone areas • Construct flood infrastructure that would redirect floodwaters, subdivide larger basins, or isolate inundation • Improve awareness of floodplain function and risk through outreach and education	• Potential to create open space, recreation, and ecosystem habitat opportunities • Promote collaboration between water resource management agencies and land use entities	• Land acquisition and/or land use conversion

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Table 28-1. Flood Management Action Categories

Flood Management Action Category	Specific Management Actions	Potential Integration Opportunities	Potential Integration Challenges
Flood Infrastructure (*levees/floodwalls, bypasses, hydraulic structures, debris basins, storm surge barriers, etc.*)	• Improve conveyance by addressing flow constrictions • Increase capacity of existing bypasses • Modify existing structures to improve flood system performance • Construct new bypasses and levees or floodwalls • Raise levees to improve flood system performance • Construct closure structures and debris basins • Preserve active washes • Nourishment of dunes and beach • Construct storm surge barriers, armoring and shoreline stabilization structures	Depending on the type of infrastructure, integration opportunities can include: • Groundwater recharge • Improved ecosystem functions and habitats • Increased recreation opportunities • Improved water quality • Increased water management flexibility of reservoir operations	• Inappropriate water quality for recharge (e.g., pollutants, sediment) • Impedance to fish passage • Encroachment, right-of-way, land acquisition and land-use conversion issues
Floodplain and Reservoir Storage and Operations	• Construct new or enlarge existing floodplain storage • Increase on-stream flood storage capacity • Restore storage in existing reservoirs • Increase flood control in foothill and upper watershed storage • Increase flood control allocation by using spillway surcharge • Establish partnerships to coordinate flood management structure operations • Increase flood management flexibility through modifications to: the magnitude/timing of flood reservations in reservoirs, objective release schedules at flood management reservoirs and by implementing conjunctive use programs at flood management reservoirs • Implement advanced weather forecast-based operations to increase reservoir management flexibility	• Groundwater recharge • More natural hydrologic regimes to support floodplain ecosystem functions and habitats • Increased cold-water pool and operational flexibility for fisheries management • Increased recreational or open space areas • Improved water quality • Increased surface water storage and water management flexibility • Increased hydropower generation	• Poor water quality for recharge (e.g., pollutants, sediment) • Temperature-induced habitat changes • Land acquisition and/or land use conversion • Reserving storage for flood management reduces storage for water supply • Facility ownership and authorized purposes

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Table 28-1. Flood Management Action Categories

Flood Management Action Category	Specific Management Actions	Potential Integration Opportunities	Potential Integration Challenges
O&M	• Restore channel form and function to improve O&M and facilitate flood damage reduction • Perform regular channel maintenance • Develop regional channel vegetation management plans • Develop encroachment management programs • Protect vulnerable levees and banks through stabilization and erosion repairs • Revise O&M manuals to be consistent with new and current policies that support multi-benefits of the flood system • Develop a long-term sustainable and implementable Levee Vegetation Management Strategy • Conduct dam safety inspections and investigations	• Beneficial reuse of dredged materials • Invasive species management • Revegetation of natural plants for erosion control • Livestock grazing for vegetation management	• Complex institutional, jurisdictional, and regulatory issues
Flood Preparedness, Response, and Recovery	• Coordinate flood response planning and clarify roles and responsibilities related to flood preparedness and emergency response • Improve communication and public awareness of emergency response procedures and terminology • Establish standard flood warning systems and procedures • Improve stream gage network for forecasting purposes • Establish or improve instrumentation for early warning systems for flood facilities • Create Emergency Action Plans to address dam failure • Protect critical infrastructure corridors from flood waters • Increase financial liquidity of local agencies during flood emergencies • Improve evacuation planning • Develop post-flood recovery plans • Purchase and pre-position flood fighting materials/tools in preparation for a flood event • Integrate environmental compliance and mitigation • Participate in the StormReady and TsunamiReady Program	• Promote collaboration among agencies and entities by coordinating communications tools and protocols, shared training opportunities for standardized emergency management systems and Flood-Fight Methods, common or integrated flood emergency action plans, and shared vulnerability assessment and awareness • Build stakeholder support • Reduce potential damages and liabilities and improve overall financial stability	• Overlapping/lack of jurisdiction among agencies and entities are confusing to both the public and governmental agencies at every level

Table 28-1. Flood Management Action Categories

Flood Management Action Category	Specific Management Actions	Potential Integration Opportunities	Potential Integration Challenges
Policy and Regulations	• Encourage compatible land uses with flood management system and floodplain function • Designate lands for dedicated flood flows • Use Building Code amendments to reduce consequence of flooding • Encourage multi-jurisdictional and regional partnerships on flood planning and improve agency coordination on flood management activities • Develop and implement criteria and processes for achieving a higher level of flood protection • Clarify flood management responsibilities for local, regional, State, and federal agencies	• Land use policies can create open space, recreation, water supply, and ecosystem habitat opportunities • Opportunities for greater coordination across agencies and jurisdictions	• Complex institutional, jurisdictional, regulatory, and funding issues
Permitting	• Develop regional and corridor conservation plans, or expand existing regional conservation plans to provide a more efficient and effective regulatory approval process for flood projects • Develop regional advanced mitigation strategies and promote networks of both public and private mitigation banks to meet the needs of flood and other public infrastructure projects • Develop proactive integrated regulatory compliance strategies that streamlines permitting activities • Establish memoranda of understanding (MOUs) and/or management agreements between agencies to integrate the needs to be served by flood management systems • Increase understanding of environmental permits • Corridor Management Strategy	• Ecosystem habitat preservation and restoration	• Complex institutional, jurisdictional, and regulatory issues
Finance and Revenue	• Leverage funding from multiple projects to improve cost-effectiveness and efficiency of flood management projects • Develop funding mechanisms for O&M and new flood management improvements • Establish a methodology for evaluating benefits and costs on a systemwide basis to support economic justification for projects in all community settings	• Leverage multiple funding sources • Address legislative or jurisdictional restrictions on expenditure of funds	• Subject to potential legal challenges

- **Conveyance:** Many streams and channels are used to support both flood flow conveyance and water supply conveyance. Improvements to conveyance systems for regional water supply could enhance the potential for flood flow conveyance and vice versa.
- **Surface Storage:** Most of California's larger surface water reservoirs are managed for multiple purposes, including flood management, water supply, hydropower, water quality, and ecosystem needs. Increasing local and regional surface storage has the potential to provide greater water management flexibility for capturing runoff and controlling flood flows.
- **System Reoperation:** The primary goal of forecast-coordinated and forecast-based operations is to improve downstream flood management without affecting water supply, environmental conditions, or recreation, through better hydrologic forecasting and coordinated reservoir operations.
- **Recharge Area Protection, Conjunctive Management, and Groundwater Storage:** Diversions of flood flows for groundwater infiltration can reduce downstream flooding and improve water supply. The generally flat topography of natural floodplains and the permeable nature of alluvial soils promote infiltration into the subsurface for storage in soils and aquifers.
- **Land Use Planning and Management**: The way in which we use land—the type of land use, transportation, and level of use—has a direct relationship to flood management. One of the most effective ways to reduce vulnerability to flooding is through careful land use planning that is fully informed by and reflective of applicable flood information and flood management practices. By focusing compact development in established urban areas and avoiding more development in floodplains, the need for expensive flood facilities can be minimized and flood risk can be reduced, protecting critical infrastructure and easing the burden on flood management. Also, protecting existing floodplains and restoring degraded floodplains can provide attenuation of floods, groundwater recharge, sediment transport, and other natural processes.
- **Watershed Management**: Watersheds are an appropriate organizing unit for managing floodplains. Restoring, sustaining, and enhancing watershed functions are key goals of flood management related to integrated water management.
- **Urban Runoff Management:** Urbanization creates impervious surfaces that reduce infiltration of stormwater and can alter flow pathways, as well as the timing and extent of flooding. Impervious surfaces increase runoff volumes and velocities, resulting in streambank erosion and potential flooding problems downstream. However, watershed approaches to urban runoff management attempt to capture, treat, and use urban runoff for beneficial uses in a manner that mimics the natural hydrologic cycle.
- **Agricultural Lands Stewardship:** Due to the flat topography and rich soils caused by historical flood deposits, floodplains are often ideal for agricultural uses. Agricultural conservation easements keep land under private ownership and management, prevent urban development within floodplains, and alter farming and ranching practices to those compatible with floodplain management.
- **Forest Management**: Forestry practices can influence not only sediment transport from upland streams but also the timing and magnitude of peak flows. The extreme roughness of the surface of forested floodplains reduces floodwater velocities, spreads flood flows across a larger area of the floodplain, and attenuates downstream flood flows. Wildfires can increase peak flows and reduce surface water infiltration, which can cause erosion and debris flooding.
- **Pollution Prevention:** Floodplains that function well improve water quality by filtering impurities and nutrients and by controlling erosion and sedimentation of streams.

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- **Water-Dependent Recreation:** Floodplains are often ideal locations for parks and numerous other outdoor activities, such as water-oriented sports, boating, swimming, hiking, soccer, and camping. Flood management facilities can improve recreational access to waterways by providing opportunities for integrating suitable recreation facilities, such as trails, picnic sites, wildlife-viewing areas, and water trail launching sites. Establishing greenways as part of flood management projects and replacing concrete channels with more natural creek environments can help to meet recreation demands in urban areas.
- **Outreach and Education:** Outreach is needed to regularly educate residents and policy makers about flood risks, land use planning, and to explain what households, businesses, and communities can do to reduce or mitigate risk to acceptable levels. Outreach is also needed to educate the public on the natural, beneficial functions of floodplains.

The management actions that have a direct impact on other resource management strategies are shown in Appendix A.

Potential Benefits of IWM Approach to Flood Management

Flood management benefits derive from the potential to reduce risks to lives and property from flood events, which reduces social and economic disruption along with saving costs of flood recovery; other advantages derive from collective benefits gained from protecting or restoring ecosystems. Implementing an approach to flood management in the context of an integrated water management expands the benefits of traditional flood management, which were focused primarily on protecting people and property. Through an IWM approach, additional benefits can be realized, as follows:

- **Agency alignment:** Improved communication, coordination, and collaboration
- **Reliable funding:** Partnerships to support project delivery of collaborative, regional, and integrated approaches to flood management
- **Flood awareness:** Improved understanding from California residents and policy makers regarding flood risks
- **Flood readiness:** Improved policies, practices, and alignment between flood management agencies for disaster preparedness, response, and recovery efforts from floods
- **Land use planning:** Aligned planning, policies, and regulations for ecosystem, land, and watershed management planning
- **Risk assessments:** Shared processes, tools, data, information, knowledge, and expertise
- **Regional planning:** Collaborative, location-based solutions using best available science to solve multiple resource issues

Flood management actions are the tools (or building blocks) to facilitate integrated approaches, and a number of these actions help reduce flood risks. Some actions reduce the impact of flooding in terms of the probability of flooding, area affected, and depth of flooding. Examples include increasing floodplain and reservoir storage, streamlining storage operations, and encouraging natural hydrologic, geomorphic, and ecological processes. Other actions, such as land use planning and floodplain management, affect who and what might be harmed by flooding. Still other approaches influence the susceptibility of people and property to harm from flooding. Appendix A provides a summary of the benefits for each flood management action, as well as summarizes integration opportunities with other elements of integrated water management, including water supply and groundwater recharge, ecosystem restoration, recreation, hydropower, and improved water quality and navigation.

Agency Alignment and Reliable Funding

An IWM approach for flood management results in improved coordination, communication, and collaboration between agencies. Evaluating opportunities and potential impacts of flood management from a systemwide, regional, or watershed perspective helps comprehensively manage downstream and upstream interactions among water, sediment, habitat, and pollutants. Coordinating across geographic and agency boundaries can help engage new stakeholders, build advocacy, and pool and leverage funding, as well as address jurisdictional and facility ownership issues and restrictions commonly encountered in complex flood and water management projects. Because several State and Federal agencies have structured their flood management programs to support IWM, projects with multiple objectives often have increased access to funding sources. Additionally, the integration of flood management and ecosystem restoration can potentially reduce mitigation requirements and long-term costs of O&M.

Flood Awareness and Readiness

Floods in California differ by location, type, and cause; have warning times from minutes to days; and can result in both short-term and long-term disruption. Therefore, residents and policy makers must be aware of the flood risks in their area, understand the impacts, and know how to protect themselves. With 40 percent of agricultural land in California lying within a floodplain, understanding flood risk also is important to agriculture. Having proper evacuation plans for animals and understanding how standing water will affect crops is another important aspect of protecting the stability of the State's economy. Environmental resources can be affected by floods; therefore, understanding and providing protected habitat for species are important.

Flood management agencies protect the public and save lives and property during floods, which shields the people and economy of the state. Flood preparedness, response, and recovery policies, standards, and programs enable agencies across the state to work together effectively. Since 1997, efforts under DWR's FloodSAFE Initiative have increased the collaboration between agencies statewide. This has enabled agencies to share resources to fight floods and share expertise and lessons learned, as well as helped to identify issues that impede progress.

Land Use Planning and Risk Assessments

Prudent land use planning results in increased public safety, avoiding economic instability due to damage and loss of lives and property, and protection or restoration of natural systems. Risk assessments help agencies and decision makers understand who and what is at risk. When agencies coordinate and share information, processes, tools, and expertise, more robust and integrated solutions result, which facilitates better (and more informed) land use decisions.

Regional Planning

Regional planning leads to more holistic solutions to resolve flood management issues. Flooding is a watershed-based problem that often crosses jurisdictional boundaries; therefore, regional planning enables agencies to work together creating solutions that provide multiple benefits. For example, a local flood management agency working alone might develop a solution that solves a local flood issue but results in other unintended impacts, such as increased flooding downstream or habitat degradation. When agencies work together toward IWM solutions, the same flooding issue might be solved by restoring a wider natural floodplain in an upstream area to reduce downstream flows, diverting floodwaters for groundwater

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recharge, or reoperation of a reservoir to increase flood storage. Regional planning enables local agencies with different roles and responsibilities to work together for better resource management and for regional solutions to regulatory or permitting issues, and to leverage funding for projects.

Potential Costs of Flood Management

Relative costs for flood management were developed for each flood management action and are provided in Appendix A, including initial and annual costs. A qualitative summary of these costs is provided in the following section by management action category. Costs were not developed by benefits because these areas were too broad to be assessed.

The management action category for floodplain conservation and restoration generally has management actions with medium to high initial costs, including real estate acquisitions, relocations, design, construction, permitting, mitigation, and potential loss of property taxes. Annual costs initially increase during the establishment period, but generally decrease over the long term. Regional permitting incurs initial costs for development of habitat conservation plans or natural community conservation plans, but has little change in annual costs.

The category for land use and floodplain management actions has lower costs. Costs generally increase with the level of development. Land use planning typically involves relatively minor funding for planning and adoption, with few long-term costs. Land acquisitions and easements, on the other hand, can demand high initial costs, especially for floodplain lands that have already been developed. Floodproofing structures on developed lands also require significant initial costs, depending on the number of structures. Flood insurance, risk awareness, information, and education have low initial costs but require annual expenditures for program maintenance.

In terms of relative magnitude, the category for flood infrastructure management actions is the most capital intensive, in terms of both initial cost and annual costs. Initial costs are generally driven by construction cost, real estate needs, permitting, and mitigation costs. Annual costs consist primarily of O&M for flood infrastructure facilities.

The costs associated with the category for floodplain and reservoir storage and operations management actions vary based on whether new construction is required. Costs for increasing flood storage, increasing spillway capacity, and adding infrastructure are generally high due to construction, permitting, and land acquisition. Some operational changes can be made to systems that require little to no cost expenditures.

The costs related to the management action category for O&M increase with time as facilities age, permits are renewed, and regulations change. Also, long-term maintenance costs are often not considered when designing, constructing, and financing existing flood infrastructure projects. Increased regulations and permitting requirements over the past several decades have further increased annual maintenance costs.

The category for flood preparedness, response, and recovery management actions includes relatively low initial costs that require some long-term funding to ensure that the programs, equipment, and personnel

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training remain effective. These costs are predominantly borne by county agencies, but Federal, State, and regional agencies provide additional support when needed.

Costs associated with management action categories for policies and regulations, permitting, and finance and revenue vary depending on the complexity of the regulatory change or project undertaken.

Major Issues Facing Flood Management

One of the California Water Plan 2013 Companion Plans is the Flood Future Report. When compiling information for the Flood Future Report, the Department of Water Resources interviewed over 140 local, State and Federal agencies with flood management responsibilities in each county of the State. The agencies were asked about the state of flood management in their respective areas of responsibility. The following seven basic issue categories were identified as a result of this information gathering exercise:

- Agency Alignment
- Reliable Funding
- Flood Risk Awareness
- Flood Readiness
- Land Use Planning
- Risk Assessments
- Regional Planning

These categories form the basis for the recommendations that follow.

Future Flood Management planning and actions should proceed utilizing IWM as the overarching strategy to address these major issues and implement a balanced planning framework that promotes multiple societal benefits, including public safety, environmental stewardship, and economic stability.

Agency Alignment

Hundreds of agencies statewide with a myriad of different governance structures have flood management responsibilities. This complex governance structure makes agency coordination fragmented and difficult. Agency coordination issues include intra-agency, inter-agency, and coordination with regulatory and resource agencies. Improved agency alignment delivers a variety of benefits, such as improved flood and land use planning, improved O&M for facilities, and maximized available funding. Improved agency alignment can resolve common permitting, planning, and funding problems on a regional or watershed basis. Agency alignment also can result in projects that identify areas where natural systems and floodplains can be used to reduce flood flows while improving natural systems. For example, in the San Joaquin watershed, areas have been restored to natural ecosystems that will take peak flood flows out of the river by flooding low-lying areas.

Internal agency coordination involves sharing flood risk and land use information within an agency. Small changes to land use decisions make future flood management actions more efficient and increase public safety. For example, providing adequate easements along rivers, creeks, and channels in areas where land is being changed from agricultural to urban uses can reduce the cost and complexity of flood management facilities. Flood managers working with planners can develop multi-benefit projects that provide extra value to the community. For example, flood detention basins can be developed to provide environmental or recreational opportunities during dry periods.

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Facilitating interagency coordination is important to share expertise and flood information, and to leverage resources for multiple benefits. For example, sharing information for system operations enables agencies to work together to release water from reservoirs before a storm, which can provide ecosystem or water supply benefits.

Developing alignment between resource and regulatory agencies is important to keep existing projects operational, implement new systemwide solutions, and reduce project costs. Currently, local agencies are facing challenges with O&M of existing projects due to increased permitting requirements, conflicting guidance between permitting agencies, and lengthy review periods. Local agencies working together might be able to work with resource agencies to develop programmatic approaches to permitting some activities based on compliance with regional habitat conservation and other plans.

Better agency alignment is important because improved coordination results in more effective handling of flood management issues.

Reliable Funding

Between $32 and $52 billion for flood management improvements and projects have been identified throughout California by local, State, and Federal agencies to meet near-term needs. However, billions more are needed to provide protection for 100-year flood protection statewide. At current funding levels, it would take over a hundred years to reach this basic level of protection because current funding sources do not satisfy existing project planning and implementation needs, and will continue to fall further behind over time. In Orange County alone, it is estimated that $2 billion of flood improvements are needed to provide 100-year flood protection countywide, which are not included in the near-term statewide improvement estimates. The county estimates that it will take 90 years to complete these investments at current funding levels.

Many flood management responsibilities in California rest on local agencies that report having inadequate funding. The costs of ongoing O&M, along with rising permitting costs on existing facilities, are consuming a large portion of local agency budgets. This leaves little funding for rehabilitation and construction. Funding for flood management programs has been cyclical—often increasing following a flood disaster, then gradually decreasing as other priorities garner the attention of residents and policy makers. Flood management budgets are especially susceptible to reductions in dry years or economic downturns. Generally, flood management budgets have not fully addressed full life-cycle O&M needs and environmental impacts. Increasing hazard exposure because of land use choices generally is not considered in agency budgeting.

Between 2001 and 2009, annual flood management funding from Federal, State, and local sources ranged from approximately $1.5 billion to $3.0 billion (in 2010 dollars). Federal and State funding show increases because of $4.9 billion in State bonds authorized by Propositions 1E and 84 in 2006—that authority extends to 2017—and an infusion from the Federal American Recovery and Reinvestment Act (ARRA) in 2009. Of the $4.9 billion available for flood risk reduction in California, $3 billion were designated for flood risk reduction in areas protected by facilities of the SPFC, with remaining funding allocated to statewide flood risk reduction.

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County flood management agencies either receive part of the county's general fund or rely on assessments to fund projects and O&M. For most local agencies, revenue is generated by a type of property tax assessment or impact fees. However, the ability of local agencies to increase these assessments is limited by voter-approved initiatives, such as Proposition 13 (limiting property tax increases) and Proposition 218 (requiring voter approval for new assessments).

Funding from tax assessments or impact fees can have limitations on where the funds can be spent based on geographic location. For example, upstream infrastructure development might not be funded in a flood management assessment district because the infrastructure is not within the district's geographic boundary. Some agencies are able to supplement local revenue with Department of Water Resources (DWR) grants and/or U.S. Army Corps of Engineers (USACE) project funding, but these sources are not consistently or reliably available.

When local flood management agencies rely on the county's general fund, flood projects must compete with a variety of other local needs for funding. With declining revenues available to local governments, funding for flood projects is often inadequate to keep pace with the needs for new construction, repair and rehabilitation of existing facilities, and O&M costs.

State and Federal agencies historically have collaborated with local agencies to help fund projects. Local agencies have relied heavily on State funding for O&M and on Federal and State funding for development of new projects. Flood management efforts have received Federal sponsorship since the late 1800s and funding appropriations since the 1900s. USACE has been the primary Federal agency to administer funds for projects in California. The Federal Emergency Management Agency (FEMA), Bureau of Reclamation (Reclamation), and Natural Resources Conservation Service (NRCS) also sponsor efforts in California related to flood management.

Most major flood management projects have been supported by a partnership among USACE, DWR, and one or more local agencies. Few significant water projects did not rely on Federal funds. There have also been hundreds of smaller cost-shared projects. Historically, DWR and USACE have collaborated on projects for the State Plan of Flood Control (SPFC). Outside the SPFC, the emphasis has been on USACE and local partnerships. Due to the different types of funding sources in California, flood management has focused on a location-specific single-purpose formulation of projects. This approach will have to change in the future to maximize funding. IWM enables agencies to work with different stakeholders, as well as with local, State, and Federal agencies to identify multiple funding sources and mechanisms to support project development.

Flood Risk Awareness

One in five Californians lives in a floodplain, and a majority of Californians works or relies on infrastructure (goods and services) in floodplains. Even with this significant risk to flooding in the state, residents and policymakers have varying levels of understanding about exposure to flood risk and the consequences of flooding, and might make decisions about land use and home ownership that put people and property at unnecessary risk.

Currently, the only awareness that many California residents and policy makers have of exposure to flood hazards is through the National Flood Insurance Program (NFIP). This awareness might not include the

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risk of potential impacts that a flood event might have on critical facilities, neighborhoods, and local economy. A number of existing programs are focused on improving flood awareness, including FloodSmart, FloodSAFE, Risk MAP, plus other local, State, and Federal efforts. However, coordination and information sharing between these efforts could be improved.

Also, the role and benefits of maintaining and restoring natural floodplains are not completely understood by some residents and policy makers. Understanding the full cycle of flooding includes knowing that upstream alterations can impact (positively or negatively) downstream environments.

Another issue that creates confusion in the public is that no common lexicon exists for local, State, and Federal flood management programs to describe flood risk to residents who have no engineering or risk management background.

Flood Readiness

In California, flood emergency preparedness, response, and recovery responsibilities are often fragmented among local, State, and Federal agencies in a region and even within different departments of a single agency. Each county in California is responsible for assisting local communities in the event of a flood. DWR, in conjunction with California Emergency Management Agency (Cal-EMA), provides support and coordination to and among counties or regions in preparation for, during, and after flood emergencies. USACE supports FEMA to provide Federal assistance for emergencies, including flooding, at the behest of the State.

These layers of responsibilities are complicated by the thousands of agencies that have differing governance structures and have some type of flood management responsibility. Local agencies that have responsibility for flood management include Cities, Counties, Community Service Areas and Districts, Drainage and Storm Drainage Districts, Flood Control Districts, Irrigation Districts, Levee Protection Districts, Joint Power Authority, Public Works Districts, Public Utilities Districts, Reclamation Districts, Resource Conservation Districts, Sanitation or Sewer Districts, Water Agencies and Departments, Water Conservation Districts, and others. Each of these agency types has its own governance structures that specify roles, responsibilities, and funding for the agency. Because of the complex nature and number of agencies involved, coordination efforts are difficult and not fully applied. Another issue facing local agencies is that funds for emergency planning are often the first funds cut during difficult or contracting budget cycles, which hampers proper flood readiness.

Land Use Planning

Some local agencies experience pressure to foster economic growth by approving development in areas with high exposure to floods. In other areas of the state, coordinating planning and development efforts is important to identify the need and provide easements for flood management infrastructure to meet future development. There is a conflict between (1) economic need, including support for development, (2) public safety (i.e., managing risk by limiting development in floodplains), and (3) maintaining ecosystem function. Being sensitive to local needs that foster economic growth and support development is an important component; however, informing residents and policymakers about flood risks will foster better informed local decisions about the benefits and costs associated with development in areas with higher flood risk. Also, it is important to expand the understanding of the importance of protecting

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natural floodplains and ecosystems because of the role these systems have in reducing downstream flood flows.

Currently, development proposals are done on a project-by-project basis without analysis of the long-term effects on or needs for flood management. Too often, regional and land use decision makers realize the flood risk, environmental impacts, public safety, and economic losses only after a damaging flood event. Local and regional planning agencies must modify the planning process, with coordination among planners, flood managers, resource managers, and emergency response managers to identify and plan for flood management and improve public safety by minimizing the acreage of floodplains lost to developments along with reducing the number of Californians put at risk in floodplains.

Another land use planning concern is the potential impact on public safety from future climate change. The anticipated changes in climate are projected to have a significant impact on the timing and magnitude of precipitation and runoff, which increases flood risks. Rising sea levels combined with larger storms would increase flood risks in low-lying coastal areas and the Delta. Warmer temperatures and changes in soil moisture are expected to contribute to more frequent and intense wildfires. Areas damaged by these wildfires would have a greater potential for flooding associated with accelerated runoff. These changes could increase the number and severity of events in existing floodplains, and could expand floodplains.

Risk Assessments

Identifying flood threats is an important first step toward reducing risk and prioritizing flood management needs in California, but few detailed risk assessments have been completed. A number of methods currently are used to assess flood risk, which results in confusion and inconsistent assessment of risk. These methods include those used by the USACE, FEMA, and local agencies. These different methods were developed to reach different objectives that required different levels of complexity. For example, FEMA uses an approach that has traditionally focused on the hazards associated with the 100-year and 500-year flood events, in contrast to USACE's approach that assesses and describes risk in terms of expected annual damage (EAD).

In California, only 23 risk assessments using the USACE methodology have been performed in the last 10 years. The most complete assessment in the state was completed in the Central Valley for the area covering the SPFC. Santa Clara, Marin, Monterey, Ventura, Orange, Los Angeles, and San Luis Obispo counties have developed guidelines or approaches to project planning that consider several of the components needed for a full risk assessment as defined by USACE for parts or all of their systems. Before any risk assessments can be performed, data and mapping assistance are needed in large areas of the state to improve understanding of floodplains and the impact of climate change. Then, a consistent method of assessing risk could be undertaken that would lead to a better understanding of flood risk, as well as more effective use of limited funding for flood management.

Other benefits of understanding flood threats regionally are that existing floodplains can be defined and opportunities to reduce risk and improve natural systems can be identified. Reconnecting historical rivers and streams with a floodplain is another feature that should be included when identifying methods to reduce the threat of flood risk.

Regional Planning

Historically, flood management projects primarily were developed to address a site-specific, single-purpose problem. Today, due to the complex environment of regulatory, permitting, and water management agencies, this approach no longer is effective. The water system in California must balance flood management, water supply, environmental sustainability, and other regional goals. Therefore, it is important for flood management agencies, along with other water agencies, to work together on a regional basis to develop integrated water management approaches.

In existing IWM efforts, flood components of projects have made up only a small percentage of the projects developed. Traditionally, flood management agencies have not been immersed in the California IWM process. Setting up a framework that brings local flood management agencies together to work on regional solutions is an initial step toward greater integration into the IWM process in California. Developing regional flood management planning areas is the first step in more completely integrating flood management into the IWM process.

Recommendations to Facilitate Flood Management

Flood management in the future will require unprecedented integration among traditionally disparate agencies with overlapping and sometimes conflicting goals and objectives. More reliable funding and improved agency alignment is required at all levels. Updated technical and risk management approaches will be needed to protect the public from flooding by assessing risk, as well as by improving flood readiness, making prudent land use decisions, and promoting flood awareness. Project implementation methods would benefit from integrated water management based approaches to leverage the limited funding and other flood management resources. In short, future solutions should be aligned with broader watershed-wide goals and objectives and must be crafted in the context of IWM.

Note- Yellow highlights denote 2009 CWP RMS Recommendations or other non-SFMP recommendations; and Blue highlights denote funding recommendations that may be moved or have linkages to Finance Section

Agency Alignment - Facilitate and direct agency alignment to expedite priority projects and encourage IWM

1. **DWR should identify regional flood planning areas** - Establish flood management planning regions throughout the state with boundaries that are systemwide, watershed based, and consistent with existing Federal and State agency boundaries, including existing Integrated Regional Water Management (IRWM) Plan funding areas.
2. **DWR should establish regional working groups to achieve streamlined permitting, planning, and implementation of flood projects** - Local, State, and Federal agencies should work together to develop solutions and work through regional issues. These agencies could also work together to incentivize resource agency participation in regional working groups that focus on flood project planning and implementation. These working groups would provide a forum to prioritize projects, facilitate discussions about permitting, and address regional issues.
3. **DWR should support local agencies with funding and grant programs for projects that deliver regional benefits** - State and Federal agencies can incentivize local agencies

to align for faster project delivery and multiple benefit projects by realigning grant programs and requirements.

Reliable Funding - Establish multiple approaches to achieve reliable funding while incentivizing IWM

4. **Local, State, and Federal agencies should align current and future resources to implement priority flood projects and programs** - Current funding criteria and processes are complex and hamper the development and implementation of priority projects. Programs such as the DWR subventions funding program, FEMA and NRCS grant funding, and other programs could be realigned to weigh funding toward multiple-benefit or watershed-based projects.
5. **DWR should assess the viability of all potential funding sources and propose new funding options to provide more stable flood management funding** - Flood management partners should work together to propose changes or alterations to local funding restrictions by pursuing exemptions to existing statutes for public safety. For example, changes to Proposition 218 legislation could include reclassification of flood management agencies as exempted public safety utilities or the establishment of regional assessment districts.
6. **State and Federal agencies should improve and facilitate access to funding sources** - Develop a central online resource catalog that describes the different funding programs, as well as how to apply for funding for local agencies.
7. **State and Federal agencies should increase funding for flood management projects** - Local and State agencies must work together to advocate for reliable funding sources.
8. The State should explore additional funding options for local government preparation of revised General Plans and land use regulations that address flood risks, and for floodplain function restoration projects. State funding for floodplain function restoration projects should be prioritized based on the magnitude of flood risks that would be avoided, and the magnitude of ecosystem and water resources benefits that would be created.

Flood Risk Awareness - Improve awareness about flood risks to reduce the impacts of flooding and improve the functioning of natural systems

9. **Federal, State, and local agencies should align existing flood awareness initiatives** - Public education efforts should share a common language to describe flood risks and recommended actions in meaningful ways.
10. **Federal and State agencies should provide State and Federal outreach program tools, templates, and other resource materials to local agencies for their use** - Shared resources save time and money and will facilitate public awareness efforts in regions where such efforts previously did not exist. Sharing resources will also help foster consistency among outreach programs.
11. **DWR should catalog, provide, and promote online information resources about flood risk programs, grants, and other related topics** - Simple access to data, case studies, budget information, and planning tools will improve local agency capabilities to identify opportunities for collaboration and integration and to receive grant funding.

Flood Readiness - Support flood emergency preparedness, response, and recovery programs to reduce risks to lives and property

12. **DWR should provide grants specifically to increase coordination among flood responders, facility managers, planners, and representatives of State and Federal resource agencies to improve readiness** - Coordination before a flood event improves emergency preparedness by identifying and reinforcing areas of expertise, available resources, and agreement about incident plans.
13. **DWR should assist flood management agencies statewide with flood-fight training and conduct flood emergency preparedness and response exercises statewide with local, State, and Federal agencies** - Table-top drills and functional exercises are a necessary part of disaster preparedness.
14. DWR should work closely with the Governor's Office of Emergency Services and California Department of Health Services to ensure a consistent approach to disaster preparedness plans and procedures.
15. DWR should take the lead in developing guidance and recommending improved, organized approaches for post-flood recovery, at the state, regional, and local levels. Creation of a statewide California Recovery Authority should be considered.
16. **DWR should identify data/forecasting needs for emergency response and water management** - Accurate and timely forecasts for flood events can increase warning time, save lives, and reduce property damage. Additional data will help improve the readiness and response to floods.

Land Use Planning - Encourage land use planning practices that reduce impacts to lives and property and protect existing ecosystems

17. **DWR should work with the County Engineers Association of California (CEAC), Floodplain Management Association (FMA), and American Planning Association (APA) to develop land use planning principles that will help local decision makers determine if property is at risk for flooding.** Secure endorsements for these principles by these groups, and promote as "industry best practices".
18. **DWR should facilitate regular coordination at all levels among land use planners, resource managers, floodplain managers, and emergency response managers** - Coordination among planners, floodplain managers, resource managers, and emergency response managers can help to reduce impacts of flooding and improve public safety.
19. Local land use agencies should not allow new critical public facilities (such as fire stations, emergency shelters, hospitals, or schools) to be constructed within the 200-year floodplain. Existing critical facilities located in flood-prone areas should be noted in the Emergency Plans prepared by local agencies, with evacuation and egress routes clearly identified.
20. The Legislature should enact a regulation that clarifies "reasonable" impacts on downstream drainage and property.
21. Local flood management jurisdictions should promote the preservation of existing floodplains, the restoration of natural floodplain functions where feasible, and the careful analysis of the interface between natural or naturalized floodplains and structural flood management systems, to ensure that erosion and debris deposition from these natural areas do not create undue hazards to downstream facilities and property.

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22. **DWR should link funding for flood management improvements to implementation of best management practices for floodplain management** - Fiscal incentives can help improve local land use planning to reduce risk to people and property.

Risk Assessments - Conduct regional flood threat assessments to prioritize actions that reduce risk while identifying opportunities to restore or maintain existing natural systems

23. **DWR should assist local agencies in identifying regional flood risks** -Because of the diversity of climate, geography, and types of flooding that exist across the state, a "one-size-fits-all" approach is not appropriate for identifying flood risks. Regional approaches that provide higher resolution information can help target specific locations that require detailed studies.
24. **DWR should assist local agencies in identifying regional flood risk reduction goals and corresponding acceptable levels of residual risk throughout the state** - Goals should be based on the number of lives and value of property at risk, degree of urbanization, number of critical facilities, type of flood, and level of acceptable risk for the region.
25. **DWR should identify and support regional flood risk evaluation methods and data to establish project priorities** - The quality and quantity of flood risk data vary from agency to agency. No standard methodology is used to evaluate risk in California.
26. DWR should develop a comprehensive statewide database on flood management and make it accessible to flood management agencies and local governments. The database should include natural floodplain resources, land use and watershed boundaries, and updated flood hazard areas.
27. **DWR should assist agencies in assessing the impacts of climate change and sea level rise** - Information about climate change and sea level rise has not been developed for all areas of the state, and many local agencies do not know how to access what is currently available.
28. Consistent with the Governor's Executive Order S-13-08, the Ocean Protection Council, the Natural Resources Agency, the Department of Water Resources, and the Governor's Office of Planning and Research should initiate a report on critical existing and planned infrastructure projects that are vulnerable to sea level rise.

Regional Planning – Use regional planning to establish priority projects using an IWM approach

29. **State and Federal agencies should expand and improve processes and programs for developing, funding, and implementing integrated water management and multi-objective projects in each region** - Explore options to encourage and incorporate a broad range of objectives and components to projects for flood and water management by working to develop common terminology for State and Federal programs that would help grantors and grantees understand the varying aspects and benefits of multi-objective projects.
30. **DWR should improve coordination between regional water management and flood management planning** - Review and make recommendations about existing State programs to identify changes that can be implemented to improve coordination between flood management and integrated water management programs.

31. **Local, State, and Federal agencies should improve processes to help foster integrated projects** - Improved guidelines and technical assistance will provide tools and incentives for local implementation.
32. Local, State and Federal agencies should improve conservation and restoration of ecological functions of riparian and wetland ecosystems in floodplains, where possible.
33. DWR should update the Statewide Flood Management Planning Flood Future Report every five years. The update should include updated risk assessment information; a summary of regional planning efforts including prioritized projects; a summary of flood readiness; a summary of flood awareness initiatives; an assessment of land use decision-making and agency alignment efforts in the context of IWM; a summary of flood-related funding needs; and, an update to the recommendations to improve flood management.

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Appendix A

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Appendix A - Flood Management
Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Floodplain Conservation and Restoration	**Manage runoff through watershed management.**	Runoff from watershed source areas increases, in varying extents, due to increases in impermeable surfaces in developed areas, soil compaction from agriculture, reductions in vegetative cover, incision of stream channels, and losses of wetlands. Runoff flood events will worsen in the next 50-100 years, as regional temperatures rise and winter precipitation falls more frequently as rain, rather than snow. The increased intensity and frequency of winter flooding may overwhelm existing flood management systems on a more regular basis, unless other efforts are taken.	Improved watershed management to enhance ecosystem function and attenuate downstream runoff, reduce the rate and magnitude of runoff during precipitation events, and lessen the need to store runoff in large reservoirs. Other desired outcomes of upper watershed management include restoration of natural communities and wetlands, additional water storage, improved water quality, and increased flexibility for water management.	Update relevant land use plans in upper watersheds to protect and increase the area of wetlands and pass legislation governing subdivisions standards. Plans should be updated to increase vegetative cover, expand wetland areas, restore meadows, install drywells to convert surface runoff to groundwater recharge, "daylighting" concrete lined or culverted drainage channels, and minimize the area of compacted or impermeable surfaces. This will increase percolation and water retention rates across broader areas and reduce the need for more expensive downstream options.	Relatively high initial costs depending on to the extent of physical construction. Costs for setback levees, groundwater recharge areas, drywells, wetland creation and right-of-way costs for easements can be high. Reduced annual costs for O&M, repair, mitigation and other permitting requirements in the long term.	Would rehabilitate key hydrologic processes in downstream area. Physical construction of wetland areas, drywells, setback levees, etc. could have some adverse environmental impacts too. Minor to substantial permitting required, depending on the project.	Local implementation may face challenges as implementation would restrict development. Institutional, legal, and funding challenges exist.
Floodplain Conservation and Restoration	**Remove unnatural hard points within and along channels.**	Unnatural hard points in or on the banks of streams (such as bridge abutments, rock revetment, dikes, limitations on channel boundaries, or other physical encroachments into a channel or waterway) can affect the hydraulics of river channels, constraining dynamic natural fluvial geomorphologic processes of erosion, deposition, and channel meander that contribute to healthy and sustainable ecosystems.	Promote natural physical processes that support essential ecosystem functions within the flood management system.	Changing the physical features of the conveyance system by removing hard points, such as rock revetment, dikes, or other structures in the stream, can improve ecosystem functions by promoting natural erosion and deposition processes, aquatic and terrestrial habitat heterogeneity, and successional habitat development. However, removing hard points should be commensurate with replacement of a feature that affords like function (e.g., level of protection, water management, vehicular passage), and must not restrict operability or maintainability of the flood protection works.	Medium to High initial costs depending on number, location, and types of hard points and treatments implemented. Could potentially increase or decrease annual O&M costs.	Reducing flow constrictions and hard points would rehabilitate physical processes, including sediment transport and channel forming processes. Potential construction impacts (temporary or permanent) associated with physical removal of hard points. Substantial permitting required.	Removal of hard points has been advocated by local governmental bodies and landowners who share in the cost and responsibility of maintaining revetment that does not reduce flood risk. Institutional and funding challenges exist.
Floodplain Conservation and Restoration	**Operate reservoirs with flood reservation space to more closely approximate natural flow regimes.**	Reservoir operators manage storage and releases for many competing uses. By altering flow regimes, the same dam that attenuates flood peaks and protects public safety also alters downstream hydrologic processes in ways that may reduce habitat complexity, limit habitat access for aquatic and terrestrial species, alter the in-stream flow regimes necessary to sustain floodplain and riparian habitat, contribute to channel aggradation, and contribute to the establishment of invasive species.	Re-operate reservoirs on a seasonal basis to support ecosystem needs while also protecting water supplies and allowing adequate reservoir storage space for flood management. Consider State and federal recovery goals for fish species in reoperation.	Determine ways in which ecosystem processes can be better supported by non-emergency reservoir operations, while still managing storage space for necessary water supply and flood management purposes. Releases should optimize duration, timing magnitude, and frequency of flows needed to sustain viable ecosystems and the inundation of floodplain habitat. Channel maintenance may benefit from flushing flows, which could assist with vegetation management and snag removal, while also serving ecosystem needs.	Highly variable initial costs. Could result in initial costs associated with modifying dam outlet features or constructing auxiliary spillways. May decrease water supply and hydropower benefits and/or increase the net annual cost to operate/maintain/repair.	Operating reservoirs to more closely approximate natural flow regimes would rehabilitate key physical processes and ecosystem functions by reducing scour and deposition of sediment, providing appropriate flows for fish migration, rearing and spawning, and providing opportunities for establishment of native riparian tree species. Permits for reoperation would be substantial as permitting with FERC would be required.	May face political and institutional opposition, as existing release patterns provide hydropower and water supply benefits to current users of the system. Re-operation will also need to show it will not hydraulically impact the flood flow regime or increase risks.
Floodplain Conservation and Restoration	**Set back levees to connect rivers to floodplains.**	Construction of levees immediately adjacent to streams, continual bank protection and channel stabilization not only reduces floodplain storage capacity resulting in larger downstream flooding, but can also severely modify natural geomorphic processes such as erosion, deposition, and channel meandering. Construction of levees also limits area available for riparian forest development resulting in loss of riparian habitat and associated terrestrial species, shaded riverine habitat, and large woody debris; reduces groundwater recharge; and, limits insect availability for foraging fish.	Expand the footprint of the flood system to reconnect floodplains, increase detention and attenuate flood flows, reduce downstream flood risks, minimize O&M costs, and restore critical habitats.	Identify areas where levees could feasibly be breached or set back from the existing low flow channel. Leverage existing knowledge and ongoing projects to identify opportunities for setting back levees.	High initial costs. Setting back levees may have significant capital cost associated with land acquisition and physical construction. Would likely decrease the annual cost to operate/maintain/repair by reducing stress on levees and attenuating flood flows.	Would rehabilitate key physical processes by reconnecting channels to historical floodplains, and enhancing sediment transport, channel and floodplain forming processes, groundwater recharge, and improving water quality, and would rehabilitate ecological functions by increasing riparian and wetland habitat area, quality diversity and connectivity, and by increasing spawning habitat and salmonid rearing habitat. Could result in moderate to substantial permanent impacts to terrestrial and agricultural habitats, and potentially to canal or seasonal wetland habitats.	Political and institutional acceptability is likely to depend on local jurisdictions. Maybe good option for rural areas to obtain adequate flood control. Institutional, funding, and community relations challenges exist.
Floodplain Conservation and Restoration	**Restore channel alignment (i.e. conduct de-channelization).**	In many areas channels have been straightened to increase the capacity and flows. Straightening of channels has eliminated adjacent habitat and often requires hardened structures to protect the bed and banks of the channel, thus further eliminating habitat.	Restored alignment of channels that have been straightened to increase natural meanders and lateral bed and bank of the channel. De-channelization would be accomplished without sacrificing the sustainable operability and maintenance of the flood protection works or increasing the flood risk.	Identify and evaluate sites where de-channelization may be feasible. De-channelization will provide additional flood storage capacity. This action is a proactive attempt to restore channel alignments that have been channelized/straightened.	Medium to high initial costs based on size of project, real estate acquisitions, relocations, costs for permitting, design, construction, and mitigation, and loss of property taxes. Increased short-term annual costs and decreased long-term annual costs. O&M costs may increase during the establishment period. Once a channel is restored, costs could decrease overall because a meandering channel could attenuate flood peaks.	De-channelization would rehabilitate key physical processes and ecological functions of the channel. This would in turn benefit multiple native riparian vegetation and wildlife species including special-status species. Construction activities and grading associated with this measure could have minor to moderate, temporary impacts (and potentially permanent impacts). However, these impacts may be offset by the benefits associated with de-channelization. Could reduce permitting related to O&M practices over time.	Typically, dechannelization requires an increased footprint to provide the channel room to meander. Thus, any de-channelization must consider potential conflicts with existing urban and agricultural uses, local zoning regulations, local economies, private property rights, and water rights. May be mostly applicable to smaller tributary streams. Another potential implementation challenge is defining responsibilities for long-term maintenance of restored habitat. Additionally, habitat creation projects have to compete for scarce financial resources, so implementation may be slow due to tight budgets.

Appendix A - Flood Management Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Floodplain Conservation and Restoration	**Encourage natural physical geomorphic processes including channel migration and sediment transport.**	Natural channel processes such as erosion, deposition, channel migration, formation of natural channel features (e.g. point bars, oxbow lakes), and sediment transport have been restricted by various flood management projects and operation/maintenance	A comprehensive approach to emphasize and prioritize projects and other actions that encourage natural physical processes.	Identify areas that may be suitable for restoration of natural physical geomorphic processes. Consider system-wide physical processes when proposing new projects including levee strengthening/repairs, bank erosion control, setback levees, dredging, gravel augmentation, channel alignment restoration, and large-scale vegetation planting and removal.	Medium to high initial costs based on size of project, real estate acquisitions, relocations, costs for permitting, design, construction, and mitigation, and loss of property taxes. Increased short-term annual costs and decreased long-term annual costs. O&M costs may increase during the establishment period. Once a channel is restored, costs could decrease overall because a meandering channel could attenuate flood peaks.	Would result in restoration of physical processes and improvements to ecological functions of the channel. This would in turn benefit multiple native riparian vegetation and aquatic and terrestrial wildlife species including special-status species. Likely minor to moderate, temporary impacts and potentially permanent impacts. However, these impacts may be offset by the benefits associated with habitat creation/restoration. Permitting required varies depending on the size of the project	Potential implementation challenges related to changes in existing and potential future land uses and land acquisition. Institutional, funding, and community relations challenges exist.
Floodplain Conservation and Restoration	**Remove and/or deauthorize disconnected, redundant, obsolete, and nonfunctional facilities**	There are currently facilities that are no longer functional, disconnected from the system, and/or redundant. However, maintenance resources continue to be committed to these facilities.	Identify candidate facilities for removal and develop the process for removal and deauthorization of these facilities.	Identify existing facilities that could be strong candidates for removal without causing significant adverse impacts to the respective flood system or ancillary facilities. This analysis would include the specific candidate facilities identified for potential removal, the reasons for removal, potential impacts or other implications of removal, costs of removal, and additional actions associated and/or required with removal. This would also require determining the roles and responsibilities of local, State and federal agencies and would possibly require determining the process to deauthorize levees from State and federal jurisdiction.	Medium to high initial costs. Cost of removing facilities would vary depending on the type of facility (e.g. a silted-up reservoir vs. an obsolete bypass), decommissioning and disposal requirements, and mitigation requirements. Annual O&M costs would decrease. Potential to impact water supply.	Removal of nonfunctional facilities could rehabilitate key physical processes (e.g., sediment transport balance and meander migration), floodplain and channel forming processes, and rehabilitate floodplain riparian habitat. Removal could also result in moderate to substantial permanent impacts to terrestrial and agricultural habitats, and potentially to canal or seasonal wetland habitats. Permitting would be extensive and complex.	Roles and responsibilities of local, State and federal agencies would be impacted by removing and/or deauthorizing facilities. May impact recreational use of the obsolete facility.
Floodplain Conservation and Restoration	**Remove barriers to fish passage.**	Construction of major dams that are part of the flood, hydropower, and water supply systems in California have had a major impact to California's native anadromous fish populations. Historic spawning and rearing habitat has been made inaccessible to fish. Many dams were built without legally mandated fish passage facilities under DFG code of regulations, and hatcheries were supposed to offset the impact. Hatcheries may have caused declines in wild populations of salmon and steelhead through inter-breeding and disease. Some of the major facilities, have requirements for cold water releases in order to meet temperature requirements below the dams.	Reduce the number of physical barriers to fish passage without impacting the ability to ensure public safety and limiting other water management strategies. This includes providing fish passage past the major rim dams to provide access to remaining cold water spawning and rearing habitats upstream in the higher elevation watersheds. This also includes other barriers in the system such as water diversions, culverts, etc.	Identify physical barriers which inhibit fish passage. Evaluate opportunities for enhancing fish passage through these obstructions, including installation of fish ladders or removal of the structures. Coordinate with existing State and federal fish passage removal programs. Implement feasibility studies to assess and test ladder options and other ideas for passage around dams.	Medium to High initial costs. Removal or modification of fish passage barriers and construction or reoperation of alternative water management facilities and strategies for deliveries and usage would have high initial costs. The removal of some barrier structures are unlikely to change annual cost to operate/maintain/repair.	Removing fish migration barriers would rehabilitate key ecological functions by enhancing salmonid migration and access to spawning habitat. Substantial, but less complex, permitting requirements.	Removal or modification of smaller fish passage barriers is likely to be more politically and institutionally acceptable than removal of larger barriers such as large flood control and water supply dams and weirs may face stronger political and institutional resistance. Institutional, legal, and funding challenges exist.
Floodplain Conservation and Restoration	**Improve the quality, quantity, and connectivity of wetland, riparian, woodland, grassland, and other native habitat communities.**	Significant loss, fragmentation, and degradation of native habitat types have occurred within flood management systems and their associated floodplains.	Habitat established without sacrificing the sustainable operability and maintenance of flood protection works or increasing the flood risk. Increased riparian forest restoration, leading to greater carbon sequestration and reducing our impact on global climate change.	Identify and evaluate areas to increase the quality, quantity and/or diversity of wetland, riparian, and/or other native habitat. Identify effective approaches to improve habitat and ecosystem processes that also benefit a variety of important species. Identify candidate areas that are most suitable for restoring habitat and while also meeting other benefits. Habitat enhancement and creation could be considered on a regional basis (i.e. through establishment of a mitigation bank).	Highly variable initial costs depending on the type of effort. Cost factors include real estate acquisitions, relocations, costs for permitting, design, construction, and potential loss of property taxes. Annual costs would increase in the short-term, but should decrease long-term. Increased monitoring and maintenance of restored wetlands may moderately increase the annual cost for O&M, especially during the establishment period. Increased bank stability, reduced erosion rates, attenuation of flood peaks, and reduced sediment deposited downstream could all reduce annual O&M/repair costs.	Would increase the quality, quantity and diversity of native habitat types within the flood system and could rehabilitate key physical processes and ecological functions. The restoration of these habitat types would benefit multiple native riparian vegetation and wildlife species including special-status species. Likely minor to moderate, temporary impacts and potentially permanent impacts. However, these impacts may be offset by the benefits associated with habitat creation/restoration. Possibility of mercury methylation depending on the location and type of wetland creation. Permitting requirements vary depending on the extent and nature of habitat projects.	Likely to be politically and institutionally acceptable, especially in areas that wouldn't require extensive modification to flood infrastructure. Habitat creation projects have to compete for scarce financial resources, so implementation may be slow due to tight budgets. Habitat restoration and creation must consider potential conflicts with existing urban and agricultural uses, local zoning regulations, local economies, private property rights, water rights and responsibilities for long-term maintenance of restored habitat. Institutional, legal, ,funding, and community relations challenges exist.
Floodplain Conservation and Restoration	**Create a strategic pooled money account that provides funds for land stewardship activities at current and future flood-related mitigation areas over perpetuity.**	Some mitigation areas are unable to pay for the maintenance of the habitat that has been created in response to mitigation requirements for flood control facilities. Future projects could need alternatives for funding sources for land stewardship on the mitigation areas proposed by regulatory agencies. Mitigation is not a one-time expense and needs proper planning for ongoing maintenance of mitigation areas to be funded.	Improved efficiency and cost-effectiveness of flood system land stewardship activities and associated mitigation areas.	When cost estimating is completed for a land stewardship activity, sufficient funds would be set aside for ongoing maintenance of mitigation lands. Creating a bank or other financial mechanism that pre-funds land stewardship activities would help improve efficiency and cost effectiveness, and make sure that lack of funding does not hamper achievement of land stewardship goals.	Low initial costs to implement. No direct effects on annual O&M costs.	None	Jurisdictional and institutional roles and responsibilities would need to be established; appropriate management and oversight for the funding bank would need to be identified; may require changes to existing laws or regulations governing funding for land stewardship and maintaining mitigation areas.

Appendix A - Flood Management Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Floodplain Conservation and Restoration	**Reduce the incidence of invasive species in flood management systems.**	The past and continuing introduction of aquatic, riparian, and upland invasive species can reduce the effectiveness of flood facilities by 1) decreasing the channel capacity; 2) increasing rate of sedimentation; and 3) increasing maintenance costs. Non-native, invasive plant species often out-compete native plants for light, space, and nutrients, further degrading habitat quality for native fish and wildlife. Introductions of nonnative and invasive species have contributed to a decline in the number and function of native wildlife and plant communities (Cohen and Carlton, 1998).	Effective control of species. Cost-savings and increased success from using a systemwide approach to invasive control. Updated regulations to use natives for revegetation efforts and remove uses of non-natives. Institution of best management practices for treatment and control of widespread non-native invasive plant species.	Define and prioritize by potential threat impacts non-native species and invasives potentially detrimental to recovery of native species. Coordinate regional approaches to invasives control. Initiate non-native plant species mapping within and adjacent to water channels. Use only native species for restoration projects in revegetation projects and hydroseeding, and use approved weed-free materials for erosion control. Revise and update regulatory standards to prohibit introduction of non-native species in flood management systems.	Medium initial cost. Lower cost relative to structural improvements, but potential costs related to permitting, maintenance, mapping, and technical evaluation on how to control invasive species. Increase in the annual maintenance costs to control the spread of invasive species, but over the long term, invasive removal could result in annual cost savings.	Reducing the spread of invasive plants would rehabilitate key physical processes and key ecosystem functions, because some invasive plants obstruct flow and sediment transport, cause excessive channel and bank erosion, compete with native vegetation for light, water and nutrients, and provide no or less habitat value for native wildlife species.	Likely to be politically and institutionally acceptable.
Land Use and Floodplain Management	**Reduce flood damages through acquisitions, easements, and private conservation programs.**	In many areas, natural floodplains have been reduced and floodplains are isolated from rivers and streams. This has led to constrictions to flow that create flood hazards, present maintenance problems, and to loss of ecosystem quality and function.	Acquire or otherwise dedicate floodplain land that is now not subject to flooding to the flood management system in sufficient amounts and at appropriate locations so that the increased floodplain transient storage lowers flood peaks, restores river processes, enhances ecosystem value, and contributes to water supply management.	Lands adjacent to channels and coasts that currently were flooded during periods of high flow would be inundated more frequently, at greater depths, or for longer periods of time. However, this must be balanced against the impact to existing land uses and critical infrastructure in floodplains. The use of voluntary flood easements could accommodate flood waters, preserve agricultural land, and provide habitat. In addition, private land conservation programs could be expanded through developing partnerships and incentive programs.	Potentially high initial costs depending on location and extent of floodplain acquisition. Could increase annual costs for floodplain maintenance.	Could rehabilitate key physical processes and ecosystem functions. Moderate to substantial permanent impacts to terrestrial, agricultural, and potentially to seasonal or freshwater marsh wetland habitats. Minor permitting required.	Implementation is highly variable due to location and geographical extent of land acquisition. Acquisition of some property, whether land or structures, may be necessary to ensure the effectiveness of the flood management system. Institutional, legal, funding, and community relations challenges exist.
Land Use and Floodplain Management	**Use floodproofing measures (such as wet or dry floodproofing, raising, or relocating structures)**	Structural measures cannot provide complete protection against flooding. Owners of structures located in floodplains may want to use floodproofing measures (such as wet or dry floodproofing, raising, or relocating structures).	Increase resilience of buildings, reduced flood damage and required time for recovery.	There are different floodproofing measures such as dry floodproofing (keeping water from entering a structure), or wet floodproofing (allowing water to enter the building with minimal interior damage). In order to raise a structure, utilities must be disconnected and the structure must be raised off its foundation to the new height. A new permanent foundation is then built, the house is lowered onto the new foundation, and utilities are reconnected. To relocate a structure, utilities must be disconnected, raised off foundations, and moved to their new location. Structures are then placed on their new foundations and utilities are reconnected.	Moderate to high initial costs depending on the number of structures that require floodproofing, raising, or relocation. Low annual costs. Relocation would eliminate the need for flood-related repairs.	None	This action would be easy to implement for a smaller number of structures.
Land Use and Floodplain Management	**Develop mandatory flood insurance programs that are more consistent with the area's risk of flooding.**	Under the current rules of the National Flood Insurance Program (NFIP), homes protected by levees certified by the USACE as providing one-percent chance event flood protection are not required to obtain flood insurance. However, occupants protected by flood infrastructure are still exposed to a residual risk from flooding due to unforeseen factors such as poor construction, poor maintenance, undetected rodent activity, undetected geotechnical problems, seismic events, and tsunami events. Furthermore, while flood infrastructure can reduce the occurrence of flooding, they do not protect against the consequences of more severe floods.	Those subject to residual flood risk are protected by flood insurance and property owners in all flood zones carry flood insurance.	Coordinate with FEMA to graduate Federal flood insurance premiums according to a structure's level of flood risk rather than the structure's location (based on a combination of frequency and actual damages). Additional information besides Flood Insurance Rate Maps (FIRMs) would be used for decision making. This could include creation of a flood hazard zone for areas protected by flood infrastructure and structures protected from less than the 0.5% chance event floodplain, where Federal flood insurance would be mandatory but with preferred risk options. New buildings sited within the zone would pay actuarial based insurance rates.	Variable costs, depending on the geographical extent of areas requiring flood insurance based on new flood risk zones.	Could possibly impact physical and ecological functions. Permitting decisions would be impacted in areas behind levees.	Could be difficult to implement. FEMA and the state would need to cooperate and possibly change the way flood risk is determined and the rates that should be paid for protection. This could also cause some people who were not previously considered in a flood risk area to now be required to buy flood insurance. Politically sensitive subject requiring high level coordination of Federal, State and local level. Similar proposal has been proposed at Federal level.
Land Use and Floodplain Management	**Develop a State program and framework to reduce or eliminate subsidies for repetitive loss properties in floodprone areas.**	There are instances where owners of property within the floodplain have accumulated insurance claim reimbursements equal to or greater than the value of the structure for repeated flood damages.	Reduced flood insurance liability and reduced loss of lives and property and tax burden to State and federal taxpayers.	Identify opportunities independent of FEMA to identify and eliminate subsidies for structures that are repetitively damaged. Work with FEMA and local communities to terminate Federal flood insurance for property owners who have accumulated claim reimbursements equal to or greater than the value of the structure or require reimbursements to be used towards flood mitigation measures such as relocating, elevating structures, flood proofing, or demolition if the structure is repetitively or substantially damaged.	Low/medium initial costs. This management action would save money by reducing the amount that can be paid for repetitively damaged structures by the NFIP but may require some funds for mitigation. Annual cost would be greater in first few years until program was fully phased in and benefits realized.	None	There may be resistance to this action because many payees will resist moving their structure or the redirection of insurance payments to other flood management activities. This will require a major policy change to enact. This has already been proposed at the Federal level and is met with significant political challenges.
Land Use and Floodplain Management	**Coordinate and streamline floodplain mapping to improve consistency of floodplain delineation and assessment of flood risk**	Floodplain boundaries provided by USACE, FEMA, and DWR are often different from each other due to variation in the available data and intended purpose of the map. Inconsistencies between the floodplain boundaries of multiple agencies can cause public confusion regarding flood risk.	Improved accuracy and understanding of current and new floodplain maps to help guide development, prepare plans for community economic growth and infrastructure, utilize the natural and beneficial function of floodplains, and protect private and public investments. Increased awareness of the different types of maps and their appropriate uses.	This would involve the development of a unified set of floodplain-mapping standards for the foundational data sets used for topography, hydrology, hydraulics, and floodplain delineations to ensure consistent floodplain delineation and assessment of flood frequency and risk. This would support coordination with other hazard mapping efforts to create, develop, produce, and disseminate geographic information system (GIS)-based multi-hazard advisory maps.	Medium-to-high initial costs for coordination, database, and data collection. Small increase in annual costs.	Possible indirect environmental impacts	Requires consensus on standards and database population. Potential to discourage development in floodplains.

Appendix A - Flood Management
Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Land Use and Floodplain Management	**Increase flood risk awareness through outreach.**	Among the public there is a general lack of understanding of flood risk because of limited access to information, a false sense of security and an undefined responsibility for education. Many property owners assume that if they are outside of the 100-year floodplain they are safe. Some also wrongfully assume that 100-year-certified levees will protect them against any level of flooding. State, federal, and local flood control agencies have struggled to educate the public with a comprehensive and consistent message on flood management.	Improved public awareness of flood risk, what households and businesses can do to reduce or mitigate risk to acceptable levels, need for flood insurance, requirements associated with the use, buying and selling of property, available assistance programs, what to do in a flood event and how floods might occur. Increased awareness may also help build political support for the public's willingness to invest in necessary flood management activities.	Expand outreach programs to include public service announcements, workshops, social media and other outlets that increase public awareness of floodplain values, flood risks and hazards, how FEMA maps are developed and used to assess flood risk, public safety, and hazard mitigation measures. Develop an interactive web site that would allow users to access detailed flood hazard maps. Students from K-12 could be educated about flood risks as part of their curriculum. Coordination and sharing knowledge between State and local flood managers is key. Information should be presented in a way that wouldn't result in public panic.	Low initial costs. Policy and Outreach management actions will tend to have a substantially lower capital cost than other management actions which involve physical construction. Example of capital investments include: Funding for training, education, and promoting awareness of flood risk among the public and those responsible for implementing floodplain management decisions. Low to moderate annual costs depending on how often flood information is disseminated.	None	High likelihood of implementation.
Land Use and Floodplain Management	**Increase awareness of and participation in the Community Rating System insurance-rate adjusting program.**	The Community Rating System (CRS) is a FEMA program created to encourage and recognize communities that engage in floodplain management activities that exceed minimum National Flood Insurance Program (NFIP) standards. Despite the reduction in flood insurance premiums offered to participating communities, only 14% of California communities (accounts for 55% of the NFIP policy base statewide) are participating in the CRS program. Communities lack staff and time to apply and maintain program requirements.	To increase participation and existing CRS classifications in the CRS program.	Outreach, train and educate the public and local agencies about the advantages of participating in the Community Rating System program.	Low initial costs and annual costs. The only costs associated with this action would be the creation of a CRS Coordinator position at the State level and outreach and training costs.	Could possibly improve key physical and ecological functions through stricter requirements.	This action would be easy to implement. There are other State/local programs where coordination regarding education and outreach already occur and these could be used as a model. High, great support at the local, State and Federal level for the CRS program. Also high level of public support for this program.
Land Use and Floodplain Management	**Improve awareness of floodplain function through outreach and education.**	It is important for the general public to understand the benefits of natural floodplain function and why keeping floodplains functioning properly is important. Development in the floodplain impedes natural floodplain function.	For the general public to have an understanding on the importance of natural floodplain function and to make decisions on land use and development accordingly.	Increase public awareness of floodplain values and its multiple uses, including ecosystem functions, agriculture, recreation, etc. Conduct outreach activities using already established media outlets, such as newspapers, news broadcasts, social media, etc. K-12 Students could be educated about floodplain values as a part of their curriculum. There are also opportunities for coordination and sharing knowledge between State and local flood managers, and academia on best management practices and new science to support adaptive management.	Low initial costs. Policy and Outreach management actions will tend to have a substantially lower capital cost than other management actions which involve physical construction. Example of initial costs include: Funding for training, education, and promoting awareness of floodplain benefits among the public and those responsible for implementing floodplain management decisions. Low to moderate annual costs depending on how often floodplain information is disseminated.	No direct effects; however, a well-informed public is more likely to support land use decisions consistent with floodplain function.	Improving and promoting flood education and awareness programs in communities could discourage communities from developing in floodplains. Often, the general public and politicians are not aware of the benefits of floodplain function and are only concerned about flooding events.
Land Use and Floodplain Management	**Examine potential interaction between natural hazards in assessing a community's flood risk**	Some natural hazards interact with each other causing hazards that are greater than the sum of their parts. For example, wildfires can increase the extent of storm runoff during a flood and result in the movement of post-fire debris flows within a watershed.	Land use planning and decision-making that is based on a more accurate assessment of flood risk from multiple hazards	Land use planning and decision-making would integrate the consideration of flood hazards with other hazards such as: surface fault rupture, seismic shaking, landsliding, naturally-occurring hazardous minerals and hazardous materials, wildfires, and post-fire debris flows.	Would increase costs of flood risk assessment	None	Would require a significant shift in land use planning and decision-making that would require political support, training and education.
Land Use and Floodplain Management	**Manage municipal stormwater to provide regional or systemwide flood benefits.**	Municipal storm flows exhibit accelerated runoff and higher peak flows than an undisturbed landscape. These characteristics create more scour, higher stages, more dangerous channel velocities, and generally more destructive flows, and they occur over a shorter period of time than flows from an undisturbed watershed.	Develop municipal stormwater improvements to improve flood management while also providing other benefits, such as ecosystem functions.	Stormwater management is governed and implemented by municipalities and other local agencies. There are opportunities to coordinate local stormwater management with regional flood operations and to explore the treatment and reuse of stormwater. Examples of implementation include replacement of hardscape surfaces with vegetative surfaces; use of diversion channels to collect excess surface water and convey it for infiltration; use of vegetated waterways, use of terracing to reduce the volume and velocity of runoff from sloped land; diverting floodwaters from recharge facilities to in-stream flows to improve water supply and quality.	Low to moderate initial costs to implement on large scale and no change in annual O&M costs.	Potential to provide environmental mitigation and enhancement opportunities.	Stormwater management falls under local, municipal, and state jurisdictions; large-scale implementation (to provide systemwide flood benefits) would require coordination by a large number of local, municipalities, and state agencies, which would likely require changes to stormwater policies at a regional (Cities/Counties/Integrated Water Organizations), state (Water Boards), and federal (USEPA) level. Institutional, legal, funding, and community relations challenges exist.
Flood Infrastructure	**Construct new levees or floodwalls to provide flood protection to additional areas potentially affected by flooding**	Due to changes in the land use patterns, channel hydraulics, and environmental conditions, portions of non-leveed channels may need new levees or floodwalls constructed to meet current level of safety requirements.	Construct additional levees or floodwalls as needed to improve public safety and improve the robustness and flexibility of flood management system.	New levees or floodwalls could be constructed along river reaches where no facilities are currently present to increase the carrying capacity of the existing river channel and modulate peak flows.	High initial costs, dependent on location and amount of new levee or floodwall construction. New annual O&M costs.	Substantial permanent impacts to terrestrial, riparian and shaded riverine aquatic habitats; Substantial alteration of physical processes. Extensive and complex permitting	High capital costs, environmental impacts, and significant land acquisitions may present a challenge to widespread implementation.

Appendix A - Flood Management Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Flood Infrastructure	**Raise levees to improve flood system performance.**	Levee reaches with insufficient freeboard to meet existing design criteria.	Provide an adequate level of freeboard and increase the conveyance capacity of the channel adjacent to the levee by raising levees so they meet requirements for level of safety.	Levees can be raised by the addition of earthen material or by constructing floodwalls. Raising levees could allow larger design flows, or larger project flows, to pass with adequate freeboard.	High initial cost (unless only a small levee raise). Minimum or no significant increase in annual O&M costs.	Could result in substantial permanent impacts to terrestrial habitat. Could moderately alter physical processes. Extensive and complex permitting.	Real estate acquisitions may be necessary if widening the footprint of an existing levee. Neighborhood and community opposition could be significant.
Flood Infrastructure	**Construct setback levees.**	Some reaches have insufficient conveyance caused by restrictions in the channel and/or environmental considerations that restricts maintenance activities, reduce the natural capacity of floodplains to provide flood storage and conveyance, and can cause sedimentation and scour in unanticipated places due to changes in sediment transport dynamics.	Construct setback levees where feasible to improve channel conveyance, improve the level of safety, and minimize disruptions to vital riparian corridors.	Expanding channel capacity by setting levees back from the main river could provide a sustainable approach by enhancing flood system performance and reducing levee erosion over the longer-term.	High initial costs for real estate acquisition and new construction. No significant increase in annual O&M cost, with potential for reduced long-term costs.	Could rehabilitate key physical processes by reconnecting channels to historical floodplains, and enhancing sediment transport, channel and floodplain forming processes, groundwater recharge, and improving water quality, and would rehabilitate ecological functions. Would result in moderate to substantial permanent impacts to terrestrial and agricultural habitats. Permitting is expensive and complex.	High capital costs and land acquisition challenges may present a challenge to widespread implementation.
Flood Infrastructure	**Construct ring levees.**	There are small communities and critical infrastructure that are at risk of flooding, either because they have no flood control protection or the existing flood control protection is insufficient and unreliable.	Construct ring levees where feasible to protect critical infrastructures and increase the level of protection for small communities.	Reduction in flood risk to small communities and individual structures can be achieved by constructing ring levees or internal levees. A ring levee is constructed around the protected area, isolating it from potential flood waters. Internal levees, on the other hand, serve as a second line of defense by compartmentalizing and isolating portions of the protected area.	High initial costs to obtain real estate and construct new ring levee construction. New annual O&M costs for ring levee and associated infrastructure.	Substantial permanent impacts including loss of terrestrial and potentially wetland habitat. Extensive and complex permitting required.	Generally politically acceptable. Ingress and egress from ringed areas may become more difficult during flood events. Can also segregate the community, create inequalities and limit economic growth. May promote a false sense of security for communities within ringed areas.
Flood Infrastructure	**Improve structural performance and resilience of existing flood facilities.**	Existing flood facilities in certain areas have deficiencies that increase the risks of failure during a high-water event. Deficiencies range from inadequate embankment geometry, seepage, toe erosion, foundational stability, seismic risks, etc.	Reduce the risk of failure on existing flood facilities	Flood facilities can be strengthened to enhance their integrity in several ways. The integrity of earthen flood facilities can be enhanced by improving embankment soil properties and geometry to resist slope and seepage failures. Improving resistance to slope failure can be achieved by adding material to widen the top width, flatten steep slopes, or both. Methods to address seepage include seepage berms, impermeable barrier curtains (slurry cut-off wall) in the flood facility and/or its foundation, and relief wells and toe drains. Armoring of the landside of the flood facility can improve resiliency during overtopping episodes. Seismic strengthening may be needed for some facilities.	Moderate to high initial costs depending on the extent and type of modification and real estate needed. No change or slight reduction in annual O&M costs.	If the footprint of the existing flood facilities is expanded, it could result in substantial permanent impacts to terrestrial habitat and could also moderately alter physical processes (including sediment transport).	Improving the reliability of flood facilities is politically desirable. However, costs and permitting considerations may present a challenge to widespread implementation. Real estate and right-of-way needs may generate neighborhood or community opposition.
Flood Infrastructure	**Construct flood infrastructure that would redirect floodwaters, subdivide larger basins, or isolate inundation**	If a small portion of a flood facility fails within a system that protects a large and heavily populated area, the entire area could be inundated. Constructing levees, floodwalls or other flood infrastructure that subdivides the basins could limit the inundation following facility failure. Training levees could redirect the erosive forces of flood waters to reduce the likelihood of flood infrastructure failure.	Isolated failure of a flood control system that does not inundate the entire basin (or lands) that it protects.	In areas where flood control systems protect large areas, perform analyses to determine the best location for a sub-dividing levee, floodwall, or other infrastructure to minimize and isolate the risk of primary facility failure. Perform analyses on existing flood control systems to determine areas susceptible to erosive force and failure, and construct infrastructure to reduce the risk of failure.	Medium to high initial costs. Training levees are often relatively short to be effective. Sub-dividing levees and other flood infrastructure may be very long, and be a significant cost. Both training levees and sub-dividing infrastructure would require regular maintenance, and likely significant repair and rehabilitation following flood events.	Construction of training levees could significantly impact existing riverine/riparian habitat. Construction of sub-dividing flood infrastructure may impact habitat, depending on siting. Extensive and complex permitting.	Would require State or local stakeholder leadership to succeed. Institutional, funding, and community relations challenges exist.
Flood Infrastructure	**Improve conveyance by addressing flow constrictions.**	Constrictions and vegetation such as bridges, marinas, in-channel structures, and other obstructions can trap large debris during flood events causing flood waters to backup. The backwater caused by the constrictions can increase pressure on the levees and increase sediment accumulation upstream of the restriction while incising the channel bed and/or eroding channel banks downstream. In addition, flow constrictions could impact channel's ability to accommodate reservoir's objective releases.	Increase channel or bypass flood conveyance capacity and efficiency by reducing impedance to flood flow, where feasible.	Removal, modification, or relocation of flow constrictions and hardpoints can increase overall channel capacity and/or reduce flooding upstream. This could also improve operational flexibility of reservoirs. Specific actions or treatments would depend on the type of flow constriction or hard point.	Potentially high initial costs depending on number and type of flow constrictions to be removed, replaced, or modified. Impact on annual O&M costs is variable.	Minor to moderate temporary impacts during construction (and potentially permanent impacts) to aquatic and riparian habitats. Could also contribute to rehabilitating physical processes and improving fish passage.	Highly dependent on site/location and type of flow constriction. Institutional, funding, and public relations challenges exist.
Flood Infrastructure	**Increase capacity of existing bypasses.**	Due to changes in the channel morphology, some bypasses cannot convey flood flows at their designed flow rates and corresponding design stage. This lack of conveyance results in higher flood stages in the channel and increase the stresses on the levees; thereby increasing the risks of flooding.	Increase or restore the flood conveyance capacity of existing bypasses.	Could include widening or expanding the footprint of existing bypasses to increase capacity. It could also include raising levees or berms along existing bypasses to create more flood carrying capacity. It may also require the reconstruction and/or re-operation of existing flow control weirs that direct flood flows into bypasses. This measure could also include sediment removal or vegetation control.	Potentially high initial costs depending on number and type of modifications and real estate needs. Impact on annual O&M costs is variable. Potential for water supply impact if constructions serve as in-stream recharge purposes.	Could enhance key physical processes and ecological functions by restoring more natural flow regime to bypasses within historic overflow areas. Could result in substantial permanent impacts including loss of upland habitat. Could also change sedimentation transport. Extensive, complex and potentially costly permitting required.	Bypass modification likely to be more feasible/implementable than construction of new bypasses. May face opposition from some landowners because it would restrict land use within the bypass. Institutional, funding, and public relations challenges exist.

Appendix A - Flood Management Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Flood Infrastructure	**Construct new bypasses to improve flood system performance.**	Some reaches may have insufficient flow capacity or insufficient conveyance due to lack of transitory storage and ability to attenuate the flood flows. In addition, limited funding for structural improvements may require a reevaluation on how the flood waters are routed through the flood management system.	To provide relief to the areas of the flood conveyance system that do not have the capacity to provide the required level of flood protection by constructing new bypasses to add capacity	New bypasses could be constructed to redirect damaging flood flows away from the existing channels and facilities that currently lack sufficient conveyance.	High initial costs depending on location and extent of real estate and construction needed for bypasses. New annual O&M costs.	Could be designed to enhance key physical processes and ecological functions. Could result in moderate to substantial permanent impacts to terrestrial and agricultural habitats. Extensive and complex permitting.	Feasibility would be highly dependent on location (real estate requirements, land uses or infrastructure affected), cost, and magnitude of benefits provided. Creating a new bypass means relocating people within that area. Political acceptability may be low.
Flood Infrastructure	**Construct armoring structures such as sea walls, sea dikes, revetments and bulkheads.**	Flooding and wave damage in low-lying areas from major storm events can threaten human investment.	Prevents inland flooding from major storms accompanied by large, powerful waves.	A seawall is typically a massive, concrete structure with its weight providing stability against sliding forces and overturning moments. Sea dikes are typically earth structures (sand and clay) that protect low-lying areas against coastal flooding. Bulkheads are vertical retaining walls to hold or prevent soil from sliding seaward to reduce erosion and protect against wave attack, but can also protect against flooding and wave action. Revetments are erosion resistant material placed directly on an existing slope, embankment or dike to protect against waves and strong currents.	Very high initial costs relative to "softer" approaches such as beach nourishment. Annual O&M costs are required. Sea walls must often be supplemented with beach nourishment because they enhance erosion of the seabed immediately in front of the seawall due to increased wave reflection. This results in a steeper seabed profile which subsequently allows larger waves to reach the structure.	Armoring structures can interrupt natural littoral drift processes and can starve the supply of sand to downdrift beaches. The negative, downdrift impact on the local and regional sediment budget can be a key environmental constraint. Sea walls, in particular, can trap sediment behind the structure and prevent it from contributing to sediment transport processes along the coast. Some of these impacts can be reduced with beach nourishment.	Armoring structures have been replaced with softer approaches (such as beach nourishment) over the past several decades. Armoring structures often have less support from resource agencies due to their impacts. Some view armoring structures as having negative impacts to aesthetics, surfing, views of the coastline, and access to public beach and swimming areas.
Flood Infrastructure	**Construct storm surge barrier with movable locks or gates**	Storm surge flooding and related wave attack can impact estuaries. Excessive intrusion of salt-water wedges during high-water episodes can also occur.	Protection of estuaries against storm surges, but maintains tidal estuaries and can potentially allow for navigation	A storm-surge barrier separates an estuary from the sea by movable locks or gates. The movable gates would stay open during normal conditions, but close at very high storm-surge events. The closed gates help armor the shore during storms. The gates are sliding or rotating steel constructions supported in most cases by concrete structures on pile foundations.	High initial costs and high annual O&M costs.	Opening the gates would help maintain saltwater ecology of tidal estuaries	Flexibility in operation can help balance the needs of multiple stakeholders
Flood Infrastructure	**Construct shoreline stabilization, such as breakwaters, groins, sills and natural and artificial reefs**	Erosion reduces the sediment buffer zone between the land and the sea. Erosion translates into storm damage from flooding and wave attack. Chronic erosion becomes a problem due to diminished sediment supply.	Shoreline stabilization moderates the long-term average erosion rate of shoreline change from natural or manmade causes	Breakwaters are detached, generally shore-parallel structures that reduce the amount of wave energy reaching a protected area. Groins are retention structures that are perpendicular to the shoreline and act as a barrier to longshore sediment transport. Natural reefs (platforms of biotic organisms built up to an elevation) and artificial reefs (designed for shore protection, beach renourishment, and surfing) also reduce wave energy. Submerged offshore sills interrupt movement of sediments and reduce wave energy.	High initial costs relative to "softer" approaches such as beach nourishment	Shoreline stabilization that moderates coastal sediment transport processes can result in starving the supply of sand to downdrift beaches. The negative, downdrift impact on the local and regional sediment budget can be a key environmental constraint. Some of these impacts can be reduced with beach nourishment. Breakwaters and sills function by modifying the nearshore wave environment.	Coastal zone management policy in many countries and the United States presently discourages the use of groins for shore protection because of the many examples of poorly designed and improperly sited groins. Submerged stabilization such as sills and artificial reefs generally have less adverse effect on surfing conditions than surface visible structures.
Flood Infrastructure	**Beach nourishment**	Waves can erode beaches and increase coastal flood risk	Prevent shoreline erosion and protect against flooding. Beach width is increased.	Loose sediment can be placed on subaerial beach, as underwater mounds, across the subaqueous profile, or as dunes to rebuild the dunes. The material is artificially placed on the eroded part of the beach to compensate for the lack of natural supply of beach material. The increased sand buffer accommodates short-term sediment losses so that storm waves and runup dissipate over the wider fill profile. The beach fill might protect not only the beach where it is placed, but also downdrift stretches by providing an updrift point source of sand.	Low initial costs relative to traditional, "harder" approaches. Annual O&M costs include regular additions of beach nourishment.	Beach nourishment can enhance the natural environment by bringing new material to sand starved beaches and expanding the beach habitat. Widened beaches reduce the potential for new, tidal inlet formation during storms at narrow reaches of barrier islands. However, negative environmental impacts can result from offshore, sand borrow sites.	Beach nourishment can lead to recreation and tourism benefits.
Flood Infrastructure	**Nourishment of natural or artificial dunes**	Waves can erode beaches and increase coastal flood risk	Prevent shoreline erosion and protect against flooding	Dune construction is the piling up of beach quality sand to form protective dune fields to replace those washed away during severe storms. An essential component of dune reconstruction is planting of dune vegetation and placement of netting to help retain wind-blown sand normally trapped by mature dune vegetation.	Low initial costs relative to traditional, "harder" approaches. Annual O&M costs include regular nourishment of dunes.	Dune construction can enhance the natural environment by bringing new material to sand starved beaches. However, negative environmental impacts can result from offshore, sand borrow sites.	Dune construction can lead to recreation and tourism benefits.
Flood Infrastructure	**Construct debris basins**	Debris-laden flows can result from alluvial fans. Debris flows can also result from wildfires. Debris-laden flows can destroy structures, wash out roads and bridges, sweep away cars, knock down trees, and lay down several-foot-thick deposits of mud, rock, and other debris where they come to rest, obstructing drainages and roadways.	Reduction in debris-laden flooding.	Construct debris basins in areas downstream of debris-laden flows. Debris basins retain the debris and reduce downstream flooding. A spillway is usually needed to safely release flow in excess of the design storage capacity and downstream channel.	Medium to high initial costs. New annual O&M costs would be needed to clean the debris basins on a regular basis.	Debris basins often require a large footprint and additional infrastructure such as concrete channels that can result in the loss of riparian and wetland habitats.	Institutional, funding, neighborhood and community opposition challenges exist.

Appendix A - Flood Management Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Flood Infrastructure	**Preserve active washes**	Alluvial fan flooding can occur with little warning. In some other instances, the meteorological conditions that may lead to alluvial fan flooding are present or predictable, and there is time to take precautionary measures. Alluvial fan flows can be particularly hazardous, as large debris can be transported by the fast-moving, dense, and viscous matrix of slurry and boulders. Traditional approaches to addressing alluvial fan flooding (debris basins and concrete channels) have had negative impacts on ecosystem restoration, groundwater recharge, aesthetic value, and can result in significant long-term O&M costs.	Reduction in alluvial fan flooding while achieving multiple objectives (ecosystem restoration, groundwater recharge, recreation).	The wash isolates the active fan areas downstream of the apex of the fan, eliminating the need for a debris basin at the mouth of the canyon and a concrete channel for the outflow. A preserved active wash allows debris from the watershed to deposit before reaching the end of the wash. The wash provides natural indirect recharge. Development is kept outside of the wash, away from the area of greatest risk.	Low initial and annual O&M costs relative to the construction and O&M of debris basins and concrete channels.	A wash would support ecosystem functions including sediment and nutrient transport that sustain riparian habitat for sensitive and endangered species, critical habitat, movement corridors for wildlife and native plants and open space/recreation value. However, some levees are required to form the wash which will have some environmental impacts.	Although the active wash eliminates development in the area, it provides open space, which is often viewed by adjacent residents as desirable.
Flood Infrastructure	**Construct closure structures.**	Many levees/flood walls are interrupted by crossings and other at-grade penetrations that lower the flood control structure elevation. Such crossings include railroad tracks, roads and highways. Many of these gaps include structures that would be closed during periods of high water to complete the flood control closure, and prevent inundation of the protected area. Some gaps do not currently have closure structures, which may reduce the level of protection of the surrounding flood control system, and put the protected lands (and lives) at risk.	Gaps in alignments modified to include closure structures where warranted.	All gaps would be identified and gaps without closure structures would be evaluated to assess whether a structure is warranted. New closure structures (i.e. flood gates) would then be constructed.	Variable initial costs, depending on location, type, and use. Very low annual costs. Annual costs are associated with operational drills and upgrades to the closure structures.	Potential for adverse environmental impact exists during construction of new structures.	Likely to receive local public support. If a gap is identified in a flood control system, there is likely an impact to level of protection of the surrounding flood control system. Construction of a closure structure would benefit the entire flood control system and lands that are being protected.
Flood Infrastructure	**Modify existing weirs, overflows, or relief structures to improve flood system performance.**	The performance and operation of weirs and flood overflows can be negatively affected by factors such as accumulation of sediment or debris, downstream flow restrictions, antiquated control systems, subsidence, erosion, structural deficiencies, and functional obsolescence. Their design parameters (how the flows are regulated), may be functionally obsolete due to changes in the flood flows caused by differing land use, climate, and weather patterns.	Improve flood system operations and performance by modifying existing weirs and overflows; Provide or restore flood conveyance and storage; Make water control structures that are robust and flexible to meet current and future flood management needs.	Weirs could be modified in several ways (raised, lowered, lengthened, or automated, changing the weir sill elevation) depending upon the operation and desired effect.	Moderate to high initial cost to raise, lower, lengthen, or automate weirs depending on the type, operation, and desired effect. Potential to reduce annual O&M costs. Potential to impact water supply if existing weirs are used for groundwater recharge.	Varies by implementation. Could enhance key physical processes and could moderately alter physical processes downstream. Substantial permitting likely needed.	Institutional and funding challenges exist
Floodplain and Reservoir Storage and Operations	**Construct new or enlarge existing transitory floodplain storage.**	Insufficient flood management storage available to manage downstream flooding	Reduce or attenuate flood peaks by increasing available transitory flood management storage	Transitory storage occurs when peak flows in a river are diverted to adjacent off-stream storage areas. Once flow in the river decreases, water in the transitory storage area may flow or be pumped back into the river channel. Enlargement of existing transitory storage areas may involve new or modified outfall structures and weirs, or modifications to berms or training dikes to increase available storage area. New transitory storage areas could be attained by natural means or could be engineered using weirs and bypasses, or by converting existing land use to serve as transitory storage.	Medium-to-high initial costs, depending on location and extent of required modifications or construction (cost factors include real estate acquisitions, relocations, mitigations cost, and complexity of any structural modifications). Potential for small increase in O&M costs.	Could help rehabilitate physical processes and ecological functions if transitory storage is located in historical floodplains or flood basins. Potentially extensive or complex permitting.	Institutional, funding, and political challenges exist, but generally less than other types of new on-or off-stream storage. Neighborhood and community opposition could be substantial in urban settings.
Floodplain and Reservoir Storage and Operations	**Increase on-stream flood storage capacity by building new storage facilities or updating, modifying or replacing existing flood storage facilities.**	There is insufficient flood management storage available in some existing flood management reservoirs to regulate flood flows. New storage facilities would provide additional flood management storage. Certain existing dams may have been built to different standards and sizes or for different purposes than those required today, or they may be aging to the point that O&M and safety considerations suggest retrofit or replacement. Replacement or retrofit of an existing dam can provide increased safety, flood management and/or water supply storage, and operational flexibility.	Increase public safety, flood management and/or water supply storage, and systemwide operational flexibility by constructing a new on-stream reservoir or modifying or replacing existing storage facilities. Modifying or retrofitting a dam can reduce the possibility of dam failure during storm events.	Constructing a new flood management reservoir would provide additional flood management storage to allow better management of flood flows to decrease the probability of releasing damaging flows downstream. The new reservoir could also be designed to provide multipurpose benefits as applicable. Replacing a dam could be done by constructing a new dam either upstream or downstream from the existing dam, and then decommissioning or removing the old dam when the new one is completed. Retrofitting a dam could include a new spillway or could raise the top of the dam to increase storage capacity.	High initial costs depending on location and size of storage (cost factors include real estate acquisitions, relocations, mitigations cost, and complexity of dam facilities). New storage would result in increased O&M costs. Modifying or replacing storage facilities may potentially reduce O&M costs.	Substantial impacts to aquatic and riparian habitat. Increasing storage would alter upland habitat and physical processes. Extensive, complex permitting required.	Significant institutional, funding, and political challenges exist
Floodplain and Reservoir Storage and Operations	**Restore storage in existing reservoirs via dredging activities.**	Due to location and/or watershed characteristics, many reservoirs have reduced capacity resulting from sediment accumulation within the reservoir.	Increase available flood management storage allocation in existing reservoirs.	Lost flood management storage could be restored in an existing reservoir by dredging accumulated sediments; this dredged material could be used elsewhere in the system for flood maintenance activities.	Moderate initial costs depending on location and extent of dredging and availability of disposal sites.	Moderate to substantial temporary impacts to reservoir aquatic habitat and associated species, moderate alteration of downstream physical processes. Substantial permitting requirements.	Significant institutional, funding, and political challenges exist.

Appendix A - Flood Management Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Floodplain and Reservoir Storage and Operations	**Increase flood control allocation by expanding existing, on-stream reservoirs.**	There is insufficient flood management storage available in some existing flood management reservoirs to adequately regulate flood flows.	Increase available flood management storage allocation in existing reservoirs.	Raising an existing dam and thereby enlarging the existing flood management reservoir could provide additional flood management storage allocation while at the same time maintaining or increasing conservation storage. Increasing flood management storage allocation in an existing reservoir usually comes at the expense of conservation storage, except when the existing dam is raised to increase the total storage behind the dam.	High initial costs depending on location and size (cost factors include real estate acquisitions, relocations, mitigations cost, and complexity of structural modifications to existing dam facilities). Little to no change in annual O&M costs.	Permanent impacts to aquatic and riparian habitat in the reservoir inundation area and moderate to substantial alteration of physical processes. Extensive and complex permitting.	Significant funding, institutional, and political challenges
Floodplain and Reservoir Storage and Operations	**Increase foothill and upper watershed storage.**	There is insufficient flood management storage available in some existing flood management reservoirs to regulate flood flows. The flood management allocation space requirements drive mandated releases during the flood season to maintain flood storage within the operational flood encroachment curve (Hegedus and Shibatani, 2009). The availability of additional flood storage in upper watershed reservoirs can reduce the required flood storage in the foothill flood management reservoirs.	Increase available storage in upper watershed reservoirs, upstream from flood management reservoirs.	When storage is available in reservoirs upstream from a flood management reservoir during flood season, that storage can often be counted as available flood storage. While upstream reservoirs cannot be operated for flood management, incidentally available storage in existing upper watershed reservoirs could be increased by allowing surcharging of the spillways, to increase the storage in the reservoir prior to spills.	Moderate to high initial investment depending on location and extent of spillway modifications (cost factors include real estate acquisitions, relocations, mitigations cost, and complexity of structural modifications to existing dam facilities). Little to no change in annual O&M costs.	Moderate to substantial temporary or permanent impacts. Potentially significant changes in physical processes. Extensive and complex permitting.	Institutional and political challenges
Floodplain and Reservoir Storage and Operations	**Increase flood control allocation by using spillway surcharge.**	There is insufficient flood management storage available in some existing flood management reservoirs to regulate flood flows. From a flood management perspective, maintaining sufficient flood reservation space within reservoirs becomes critical during the rainy season. The deep empty space requirements often drive mandated releases during the flood season to maintain flood storage within the operational flood encroachment curve (Hegedus and Shibatani, 2009).	Increase storage in foothill flood management reservoirs.	It may be possible to increase the available storage in existing flood management reservoirs by allowing surcharging of the spillways, to increase the storage in the reservoir prior to spills. The use of surcharging is dependent on the design of the dam and spillway, but if it does not reduce the safety of the dam, it could be achieved through modified operations of gated spillways and the use of temporary or permanent flashboards on top of ungated, auxiliary spillways.	Moderate to high initial investment depending on location and extent of spillway modifications (cost factors include real estate acquisitions, relocations, mitigations cost, and complexity of structural modifications to existing dam facilities). Increased annual O&M costs.	Moderate to substantial temporary or permanent impacts. Potentially significant changes in physical processes. Extensive and complex permitting.	Institutional, funding, and political challenges still exist.
Floodplain and Reservoir Storage and Operations	**Increase flood control allocation by expanding existing or building new off-stream storage.**	There is insufficient flood management storage available in some existing flood management reservoirs to regulate flood flows.	Increase available flood management storage allocation in existing reservoirs.	Construct a new off-stream storage reservoir and necessary conveyance facilities. This reservoir would likely need to be built in relatively close proximity to the existing reservoir so that water could be transferred easily from the flood management reservoir to the off-stream reservoir. Prior to and during flood season, the availability of storage in the off-stream reservoir could allow water to be diverted from the conservation pool in the flood management reservoir to the off-stream storage reservoir. This would increase the flood management storage in the flood management reservoir while at the same time saving the water diverted from the conservation pool into the off-stream reservoir to be used to replace or augment regular water supply releases later in the year.	High initial costs depending on location and size (cost factors include real estate acquisitions, relocations, mitigations cost, and complexity and size of required dam and conveyance facilities). Additional annual O&M costs and pumping costs.	Substantial permanent impacts to terrestrial and potentially wetland habitat and moderate to substantial alteration of physical processes. Potential impacts to cold water pool if on-stream reservoir doesn't fill due to drawdown. Extensive and complex permitting.	Institutional, funding, and political challenges exist.
Floodplain and Reservoir Storage and Operations	**Establish partnerships to coordinate flood management structure operations.**	The operations of flood management facilities are not always coordinated between regions or agencies and do not necessarily serve multiple uses.	Enhance coordination and modify operation of existing structures to provide better management of floods while serving multiple uses of the system.	Use new and existing partnerships to coordinate flood management structure operations. Operations of all facilities should be coordinated to reduce downstream impacts and serve multiple uses within the system. Coordinated operation may, in some instances, require modifications to existing reservoir management strategies, and institutional and funding arrangements.	Relatively low expected initial costs and potential for reduced channel annual O&M costs. May incur costs in reduced water supply benefits.	Minimal environmental impact. FERC relicensing considerations for certain facilities, potentially significant CEQA/NEPA requirements.	Institutional, legal, and political challenges exist.
Floodplain and Reservoir Storage and Operations	**Increase flood management flexibility through modifications to the magnitude/timing of flood reservations in reservoirs.**	Reservoir operations conducted by many Federal, State and local agencies are largely governed by water control manuals specific to each reservoir. These water control manuals guide operational decisions on the timing and amount of flood space throughout the year and establish objective releases. Operational constraints imposed by manuals can make systemwide, multipurpose coordinated operations and goals difficult to accomplish.	Provide better utilization of existing flood management and conservation storage for flood management.	Explore how changes to the flood reserve space can improve flood management flexibility. Modifications to reservoir rule curves could be made to specify additional downstream control points and require the coordination with operations of other reservoirs.	Low initial costs and little or no change to annual O&M costs. Changed operation could incur water supply costs.	Reservoir reoperations could be beneficial to restoring fluvial geomorphic processes needed by certain species	Modifying reservoir control manuals for flood management reservoirs would be difficult and may require congressional approval, but may not be required in all instances. Institutional, funding, and political challenges exist.

Appendix A - Flood Management Actions Descriptions

Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Floodplain and Reservoir Storage and Operations	**Increase flood management flexibility through modifications to objective release schedules at flood management reservoirs.**	Reservoir operations are largely governed by water control manuals specific to each reservoir. These water control manuals guide the timing and amount of flood space throughout the year and establish objective releases (maximum controlled release that can be safely conveyed by downstream channels). Many downstream levee and diversion systems are not capable of containing the combined objective releases of upstream reservoirs.	Provide better utilization of existing flood management and conservation storage for flood management and protection of downstream lands and facilities.	Objective release schedules should be reviewed and revised if needed based on recent data and current watershed conditions. Modifications to increase objective releases could provide more flexibility and safety systemwide and decrease the rate and quantity of required reservoir flood allocation or could reduce the flood allocation for the same level of protection. Decreasing the objective release would have the opposite effect.	Low initial costs and little or no change to annual O&M costs. Changed operation could incur water supply costs.	Potential for moderate alteration of physical processes	Modifying reservoir control manuals for flood management reservoirs would be difficult and may require congressional approval, but may not be required in all instances. Institutional, funding, and political challenges exist.
Floodplain and Reservoir Storage and Operations	**Increase flood management flexibility by implementing conjunctive use programs at flood management reservoirs.**	Maintaining sufficient flood reservation space within reservoirs becomes critical during the rainy season, and maintaining that space results in mandated releases from storage during the flood season (Hegedus and Shibatani, 2009). Conjunctive use projects may be able to use a portion of these mandated releases for groundwater recharge, where feasible.	Reduce flood risk and enhance water supply security by expanding the management tools and methods available for both flood and water supply.	Adding additional flood management storage allocation in an existing multi-benefit reservoir frequently results in a conflict with water supply storage allocation because if no changes are made to the reservoir, any increase in flood storage allocation results in a decrease in conservation storage. This conflict may be alleviated by pre-storing the water supply allocation in a groundwater bank through conjunctive use operations.	Moderate initial costs depending on location and extent of facilities. Annual O&M costs would likely increase significantly resulting from O&M for new conjunctive use facilities	Moderate to substantial permanent impacts to terrestrial, agricultural, and potentially seasonal wetland habitats. Extensive and complex permitting required, including water rights permits.	Institutional, funding, and political challenges exist.
Floodplain and Reservoir Storage and Operations	**Implement advanced weather forecast-based operations to increase reservoir management flexibility.**	During the flood season, reservoir operators currently follow the Water Control Manual and corresponding Flood Control Diagram developed by USACE for their reservoir operations. Most of the flood control diagrams often do not provide the operational flexibility needed to improve both flood protection and water supply. Flood control diagrams also do not take advantage of the most recent advancements in weather and river forecasting and data gathering and exchange to minimize the downstream impacts of reservoir releases.	Forecast-based operations provide operational flexibility based on snow accumulations in the basin, basin wetness, runoff forecasts, quantitative precipitation forecasts, and climate change. Forecast-based operations would provide operators information on future reservoir inflows and would allow them to better save the flood management storage for the peak of the storm to help minimize the risk of exceeding river channel capacity. Knowledge of future flows and reservoir releases would increase the warning times to communities along the rivers and downstream of flood control reservoirs.	Implementation would require developing weather forecasting and hydrologic models and coordinating with reservoir operators, and may require updating existing forecasting technologies.	Low to moderate initial costs, depending on whether forecasting technology (such as radars) needed to be updated. Primary initial costs consist of developing weather forecasting and hydrologic models, and establishing coordination with reservoir operators. Increased annual O&M costs if implementation includes updating the stream gage network or other forecasting technologies. Potential for increased O&M costs due to more frequent field crew deployment. Long-term flood system maintenance costs would decrease due to improved operations from flood forecasting. Reservoir operation costs would increase due to flood forecasting efforts and increased coordination with operators.	None	Forecast-coordinated operations have proven to be politically and institutionally acceptable in some instances. However, forecast-based operations may face some political and institutional resistance because they could create binding rules that would restrict the flexibility of individual reservoir operators.
O&M	**Restore channel form and function to improve O&M and facilitate flood damage reduction.**	Natural river/stream channels are formed by fairly frequent runoff events. Often, these channels are not large enough to handle peak flows from larger floods and upstream reservoir releases. This results in channels with inadequate capacity that can inhibit drainage and contribute to flooding. Narrow channels also tend to increase velocity, which can increase erosion and the risk of flood damage.	Where applicable, channels could be enlarged enough to safely carry larger peak flows without causing excessive erosion or other damage to the flood management system.	Restoring channel form and function to design standards would involve excavating a new channel or enlarging an existing channel. This would increase channel capacity and/or decrease the channel velocity. Areas adjacent to the thalweg or low flow channel can also be used to encourage or maintain sensitive habitat while other sections of the channel prism can be maintained for flow. Restoring channel form and function could occur in an existing river channel, an existing floodway, or a transitory storage area.	Initial cost is project dependent, and would likely require a moderate to high level of initial investment due to permitting, real estate needs, mitigation and structural changes. Potential decrease in annual costs.	Low flow channels can be used to encourage or maintain sensitive habitat while other sections of the channel prism can be maintained for carrying flood flows. Could result in moderate to substantial temporary (and potentially permanent) impacts to upland, riparian, and aquatic habitats. Extensive and complex permitting required.	Could have substantial neighborhood , community, and environmental interest opposition
O&M	**Perform clearing and snagging within channels.**	Snags are trees, limbs, or large bushes that have fallen into a stream or river. Once in the waterway, they can collect sediment or debris. While snags provide important ecosystem benefits (large woody debris provides excellent fish habitat), they can also migrate downstream and become stuck in the channel, which creates snag “islands” and reduces channel capacity. Snags can also cause property damage by becoming caught on bridges, pumping plants, docks, and other infrastructure. Debris also can create drag and reduce channel capacity, but in some areas may serve as bank protection.	Channels should be clear of snags and large debris to maximize capacity.	Clearing and snagging could be performed to remove snags and large debris located within channels.	Low level of initial costs and no significant change in annual O&M costs	Snagging would result in moderate to substantial temporary impacts to riparian habitat during removal and permanent impacts and loss of habitat for aquatic fish species foraging and rearing habitat. Clearing of vegetation would result in substantial permanent impacts to riparian habitat, nesting birds, and aquatic species. Substantial permitting required.	This measure would improve public safety but would reduce existing shaded riverine aquatic habitat, which is an important component to some ecosystem restoration programs. Public support may be mixed.

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Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
O&M	**Perform dredging to remove sediment from channels.**	Sedimentation of natural channels reduces their flow-carrying capacity. Sedimentation has been caused by erosion of riverbanks and levees, runoff from agricultural fields, natural sedimentation, and in some areas, historic hydraulic mining.	Channels should be clear of accumulated sediment to maximize capacity.	Dredging could remove sediment from channels and can improve the hydraulic efficiency. Deepening the thalweg or creating one can increase the overall flow efficiency by increasing the velocity through it.	Dredging projects would likely require a high level of initial costs. Dredging may reduce annual O&M costs due to less scour and erosion repair.	This action would result in moderate to substantial impacts to riparian and aquatic habitat (fish spawning and rearing habitat). It also would result in minor to moderate alteration of physical processes, including flow regime and sediment transport. Considerable and extensive permitting likely required.	Would likely need to be performed in low environmental impact areas to be implementable.
O&M	**Reuse excess materials derived from channel maintenance.**	Waste materials are created during channel maintenance activities such as dredging and clearing and snagging. It is necessary to transport and dispose of these materials, which can be costly.	These materials should be reused to minimize waste and transportation costs. This also reduces negative impacts to the environment including carbon emissions and disposal to landfills.	Beneficial reuses for waste materials from channel maintenance activities should be identified. Dredged sediment, if it does not contain hazardous materials, can and should be used where appropriate.	Reusing excess materials should reduce waste and transportation costs. No significant changes in annual O&M costs.	Environmental impacts are very project-dependent.	Reuse of excess materials would be highly likely to be implemented due to the potential cost savings and reduction in negative impacts to the environment.
O&M	**Develop regional channel vegetation management plans.**	When vegetation management has been deferred for several years due to funding or other constraints, excessive vegetation growth can result in the establishment of habitat that requires additional permits or mitigation before maintenance activities can be conducted. Conflicting guidance and requirements in relation to vegetation and debris management can make it difficult for local agencies with limited budgets to conduct maintenance activities efficiently. USACE levee vegetation policy is in conflict with the vegetation management policies of other State and federal agencies.	Develop channel conveyance management plans as part of corridor management that balance public trust concerns while maintaining the functionality of the flood management system and allows for regular maintenance to ensure public safety.	Vegetation management plans should be developed using a collaborative process involving stakeholders. Architectural Landscape designs should be developed in coordination with structural designs.	Cost of mitigation to meet federal requirements is very high. Regional vegetation management plans would slightly increase annual O&M costs, but would reduce mitigation and permitting costs.	Regional vegetation management could rehabilitate key physical processes and ecosystem functions, such as sediment transport, channel and floodplain forming processes, and enhancement of riparian and wetland habitat values. Permitting requirements are channel-specific.	Likelihood of implementation is highly dependent on the ability to meet USACE guidelines for vegetation within the project works while reducing permitting and mitigation costs. Unlikely to have substantial public safety impacts.
O&M	**Develop encroachment management programs.**	Several jurisdictions are responsible for processing, reviewing, issuing, and administrating permits for structures that encroach on project levees. There are hundreds of permitted encroachments that are not properly maintained and hundreds of unpermitted encroachments statewide. Unmaintained or unpermitted encroachments may jeopardize flood facility integrity, raise the water surface level of design floods or flows, increase the damaging effects of flood flows, and impair inspection, maintenance and flood fighting.	A streamlined permitting process, proper administration of existing permits, creation and/or improvement of a permits database and vigorous enforcement of unauthorized permits. Watercourses free of obstructions and encroachments.	Improve the administration of encroachment permits by discouraging new encroachments, removing illegal encroachments and improving enforcement of unauthorized and under-authorized permits. Improve management of historic permits data by creating or improving a repository of encroachment permits. In addition, encroachment permits should considered within the asset/legal-liability framework.	Low initial costs. No significant change to annual costs.	None.	Feasible and likely implementable. Could require significant administrative work and collaboration among many agencies
O&M	**Provide administration and oversight of levee penetrations.**	Many levees and other flood facilities have locations where irrigation lines, drainage outlets, and other utilities have been piped through the levee. Some of these penetrations are engineered but many are not and pose a potential threat to the integrity of the levees. Leaks through the levee resulting from the penetrations can cause excessive damage to flood facilities.	An inventory of all penetrations, permitted and otherwise, creation of a database for all penetrations, and an assessment of deficiencies associated with penetrations.	Improve administration and oversight of levee penetrations by creating a data management system to track, evaluate and permit penetrations. Establish a protocol to periodically conduct non-invasive testing on levee penetrations to assess their deterioration and recommend an adequate course of action. Upgrading standards for construction of new penetrations.	Cost for penetration removal varies depending on the extent of administrative improvements. Low to moderate annual costs. Most of the annual costs are associated with physical testing of levee penetrations that pose a hazard to flood protection.	Repair on or relocation of levee penetration may have temporary impacts to riparian or other habitats.	Feasible and likely implementable. Need to engage the owners and operators of levee penetrations. Small and non-urban communities may not have the necessary resources to address deficiencies found.
O&M	**Improve interior drainage.**	Localized flooding can occur even while the larger conveyance paths for streams are performing well. Local flooding can influence flooding at larger scales by increasing discharges downstream or backing up water upstream.	Improve interior drainage by channeling runoff to prevent flooding and help eliminate backwater effects and ensure each watershed has sufficient capacity.	Interior drainage could be improved by modifying or constructing new outfalls (outfalls with flap gates can prevent backflow from rivers or channels into interior areas), new or improved pump stations, or new interior drainage detention/retention facilities.	Moderate to high initial costs, but costs are project-dependent.	Wide variety of environmental impacts could result based on type of project.	Interior drainage is typically a local function and implementation would depend on local resources, needs, and acceptability.

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Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
O&M	**Protect vulnerable levees and banks through stabilization and erosion repairs.**	Erosion can encroach on existing flood facilities and ultimately result in facility failure and major flooding. Floodwaters are erosive and, while moving along typically unprotected flood facilities, need only encounter one weak spot to cause a breach and potential loss of life or property. Extremely high hydraulic gradients can find other weak spots in the foundation materials and begin to migrate, or erode material from the foundation, creating unstable conditions quickly followed by total or significant structural failure (FEAT, 1997a). In some places, ongoing erosion causes more damage than can be repaired by the State or local agencies using standard maintenance programs.	A long range solution to perform proactive repairs on damaged sites exhibiting signs of under seepage, erosion, or instability, so they do not reach a critical state of failure.	Erosion repair and bank stabilization, particularly when done in emergency situations, are made using rock riprap to armor and stabilize the bank. If conducted as part of an ongoing inspection and maintenance program, erosion repair and bank stabilization can be made more environmentally friendly by re-examining current geomorphic processes, using natural materials where practical, and including sloping riparian benches with vegetation on the bench for bank stabilization and riparian habitat. Instream habitat, such as log and debris structures to direct flows away from flood facilities could also be created as part of these repair activities.	Medium to high initial costs due to structural changes and potential mitigation. Can decrease annual O&M costs due to better performing levees and less erosion to repair	Depending on implementation, this action could result in potential temporary and permanent impacts to shaded riverine aquatic and riparian habitats. Planting of native riparian vegetation could offset some of these impacts. Levee repairs that include riparian habitat benches and instream habitat elements would rehabilitate ecological functions.	Potential for neighborhood, community, or environmental interest opposition.
O&M	**Revise O&M manuals to be consistent with new and current policies that support multi-benefits of the flood system.**	Outdated O&M manuals do not reflect the best maintenance practices to inspect, operate, and maintain levees most effectively. Many existing O&M manuals were prepared specifically to reduce flood risks, often with little consideration about how those O&M activities might affect other functions of the flood management system, including ecosystem functions.	O&M manuals reflecting best maintenance practices and scientific based approach to multi-benefit management of the flood management system, and are in compliance with current laws and regulations.	Revise O&M manuals, or provide an addendum to O&M manuals that promote best maintenance practices using the best available scientific and technical data to support multiple objectives and ecosystem benefits. The revised O&M manuals should be complimentary to achieve multiple benefits. Operations and Maintenance documents should be reviewed and updated to reflect current maintenance intervals, laws, regulations, and policies.	Low to Medium initial costs, depending on the number of manuals that need to be, and can be, updated to achieve these goals. Updating O&M manuals could decrease annual O&M costs.	Including the enhancement of physical processes and ecosystem function in O&M could rehabilitate those processes and functions.	Concerns over limiting the flexibility to maintain integrity of the flood management system must be overcome. However, the potential to provide recreation, open space, and water supply benefits will be met with support by some interests.
O&M	**Effectively maintain, operate, and rehabilitate closure structures.**	Many levees are interrupted by crossings and other at-grade penetrations that lower the top-of-levee elevation. Such crossings include railroad tracks, roads and highways. Many of these levee gaps are fitted with structures that would be closed during periods of high water to prevent inundation of the protected area. Other gaps do not have such closure structures. Some closure structures installed have not been maintained to allow functional operation during flood events.	All gaps in levee alignment evaluated periodically, and closure structures installed at gaps where warranted. All closure structures operated and inspected at pre-established regular intervals to ensure the structures will function during flood events.	All gaps on the levee control system need to be identified, and local agencies must evaluate gaps without closure structures to assess whether a structure is warranted. Existing closure structures need to be evaluated for deficiencies in design and maintenance and need to be operated on a regular basis to make sure they will operate effectively during emergencies. The State needs to establish closure structure operation drill and inspection protocols to be carried out by local structure operators.	Initial costs to design and install closure structures are potentially high. Very low annual costs associated with operational drills and upgrades to the closure structures.	Yes, there will be environmental impacts and it will be project dependent.	Existing closure structures may need to be upgraded and all need to be operated on a regular basis. The USACE requires that all closure structures be in good conditions and that trial erections have been accomplished in accordance with related O&M manuals. Institutional, funding, and community relations challenges exist.
O&M	**Develop and/or implement structure rehabilitation and repair programs.**	Many flood control structures are aging and approaching the end of their useful life. If not rehabilitated or repaired, some structures may fail or become functionally obsolete.	To have structure rehabilitation and repair programs that monitor and rehabilitate aging structures.	Create programs which monitor the status of existing structures and repairs those structures that have been identified as beyond their useful life.	Medium to high initial costs. Developing a monitoring program could be very costly depending on number of structures included in program, and ease of accessibility. Increased annual costs due to increased repair costs.	Potential for adverse environmental impact exists during rehabilitation of structures.	Substantial institutional and funding challenges exist.
O&M	**Develop a long-term sustainable and implementable Levee Vegetation Management Strategy**	In some areas, the vegetation on levees can prevent adequate visual inspections from occurring, and present access challenges. In addition, some areas of legacy levees with large wood vegetation present a challenge in implementing O&M functions to conform with all existing laws and regulations. The current allowable site-by-site variances are limiting and require significant resources to gain approval.	A levee vegetation management strategy that focuses on a balanced approach to support both public safety and environmental protection. Continued research into improving the science behind levee vegetation management.	Develop a levee vegetation management strategy that focuses on enforcing visibility and accessibility criteria, and develops a life-cycle monitoring and maintenance strategy for vegetation using a collaborative process among stakeholders. Regional variances with a broader geographic extent would be more efficient than a site-by-site variance process.	Low initial costs. Policy management actions will tend to have lower initial costs. Low to moderate increase in inspection costs, depending on the adoption of a new set of inspection criteria. Maintenance costs may also be impacted depending on the final adopted set of inspection criteria.	Vegetation removal may create adverse environmental impacts.	Policy differences on levee vegetation exist among many local, state and federal agencies
O&M	**Remove sediment from and investigate capacity of debris basins**	Debris flows gradually fill up debris basins. Debris flows can increase significantly as a result of wildfires. Debris basins must be cleaned when sediment accumulates and capacity is reduced.	Debris basins that have additional capacity to retain sediment.	State and local agencies would conduct assessments of adequacy of strategically located debris basins under a range of scenarios in urbanized areas in light of increased fire and post-fire debris-flow events. Sediment would be removed to provide additional capacity to retain sediment. Extracted sand and gravel may potentially serve as a source for fill and aggregate for local construction. However, sediment often needs to be disposed of at a landfill.	Removing sediment from debris basins is a significant long-term O&M cost. However, deferred maintenance of debris basins reduces their ability to provide flood protection.	Environmental impacts can vary dependent on how sediment is disposed or used.	Local agencies may lack funding to regularly remove sediment from debris basins.
O&M	**Conduct dam safety inspections and investigations**	Dam failure can result from earthquakes, failure of upstream dams, extreme storm events, and other factors. Dam failure can result in catastrophic flooding in areas downstream.	Dams that are regularly inspected and evaluated for safety.	Inspect dams annually to insure they are performing and being maintained in a safe manner. Conduct follow-up investigations and impose corrective actions/retrofits/upgrades as needed, such as imposing reservoir water surface level restrictions.	Low. Annuals costs for inspection and investigations are low compared to management actions that that involve physical construction.	None.	Likely to be supported by federal, State, local agencies and communities. Institutional and funding challenges exist.

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Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
O&M	**Develop funding mechanisms for O&M and new flood management improvements**	Current State and local funding mechanisms are not sufficient in many cases to adequately sustain effective flood management. Investment in flood management has declined in recent years at all levels of government. Public funds available through various State grant, loan, and bond programs have helped bridge funding gaps for many local improvement projects. However, funding for these State programs is limited by budget constraints and political subjectivity. Federal cost sharing for flood management projects has dropped in recent years.	Develop sustainable funding for flood system O&M and new flood management construction.	There are many opportunities for funding flood management actions and improvements outside of traditional taxes, bond funding, and grants. Alternate sources of funding should be considered for flood project implementation, including non-governmental organizations (NGO), local or regional funding groups, or recreation fees. For example, there may be opportunities to collect fees from areas that share in the regional or statewide benefits provided by a robust flood management system but do not directly receive flood protection.	Low initial cost to implement. Annual O&M costs would not change	None	Jurisdictional and institutional roles and responsibilities would need to be established, depending on the mechanism; may require changes to existing laws or regulations governing funding and revenue generation for O&M and other flood management activities
O&M	**Create shared strategic pooled money accounts that pre-fund avoidance/mitigation solutions for operation and maintenance impacts on current and future flood facilities.**	Lack of funding can curtail effective environmental mitigation for routine operation and maintenance (O&M). One view holds that the current process for obtaining permits and mitigating potential O&M impacts can exceed the budgets and resources of some maintaining agencies. Others contend that traditional O&M funding mechanisms were established during a time when maintenance activities were less sensitive to environmental impacts and did not consider the costs associated with O&M today.	Improved efficiency and cost-effectiveness of flood system O&M and associated mitigation.	When cost estimating is completed for a repair project or ongoing O&M activity, sufficient funds would be set aside for environmental mitigation. Funding for mitigation and O&M activities could be combined if planned in the early stages of a project. Creating a shared bank or other financial mechanism that pre-funds both O&M and mitigation would help improve the efficiency and cost effectiveness of both activities, and make sure that lack of funding does not hamper achievement of mitigation goals.	Low initial costs to implement. Could potentially reduce annual O&M costs. Funding of larger pooled mitigation areas with a single permit is more cost effective than several permits for individual sites.	Improving funding mechanisms for mitigation would improve the cost-effectiveness of mitigation	Jurisdictional and institutional roles and responsibilities would need to be established; appropriate management and oversight for the funding bank would need to be identified; may require changes to existing laws or regulations governing funding for O&M and other flood management activities
Flood Preparedness, Response, and Recovery	**Increase local agency awareness of flood mitigation compliance and grant application assistance.**	Many local agencies would benefit from assistance in pursuing Federal and State grants to mitigate flood risk. Many State and federal agencies have funding sources to assist local jurisdictions with their flood risk issues. Within these agencies, there are multiple programs that locals may not be completely familiar with. Local project opportunities are sometimes not planned or implemented because of lack of knowledge about the available grant programs. Establishing a clear roadmap for local agencies and identifying the best programs for their needs is a service that is not readily available at this time.	Increased local jurisdiction participation and awareness of various State and Federal programs available. Increased participation and awareness in FEMA's Flood Mitigation Assistance (FMA) Program, FEMA's Pre-Disaster Mitigation grant program, and FEMA's Hazard Mitigation Grant Program. Stronger partnerships and participation with all levels of government to maximize resources in support of State and Federal programs.	Increase awareness of local agencies and practitioners on the availability of FMA grants and other Federal and State programs. Greater coordination at all levels of government to integrate programs at a local, State and Federal level.	Low initial costs. Outreach management actions tend to have a substantially lower capital cost (need more staff to accomplish)than other management actions which involve physical construction. May require initial cost outlay for more staff. Potential to reduce annual O&M costs; FMA grants are used to support programs that reduce long-term risk for flood damages. Improvements to the flood control system may reduce O&M costs.	None	High likelihood of implementation; minimal costs for the State to assist localities in grant applications with large potential benefits
Flood Preparedness, Response, and Recovery	**Establish a tsunami hazard zone with consistent requirements under local, State and federal agencies**	Knowledge of the behavior of major tsunami sources of greatest concern in California and the hazards they present is only recently emerging. Coastal floodplain management efforts for tsunami hazard mitigation are being conducted in disparate efforts at the federal, state and local level.	A hazard zone that identifies the areas with greatest tsunami flooding risk	Establishing a commonly agreed upon tsunamis hazard zone that can unify requirements under FEMA NFIP, the California Coastal Commission, and local zoning ordinances and codes for regulating development would help establish a consistent framework for implementation. Tsunami hazard zone and evacuation route signs could be deployed to inform the public of these areas.	Government funding would be needed to support coordination and development of a tsunami flood hazard zone	None	Would require significant coordination across local, State and federal agencies
Flood Preparedness, Response, and Recovery	**Develop and implement criteria and processes for achieving a higher level of flood protection**	Currently, State law enacted in 2007 (Senate Bill 5) calls for urban and urbanizing areas in the Sacramento-San Joaquin Valley to achieve a minimum of 200-year (0.5 percent annual chance) flood protection by 2025. Other areas in California generally target 100-year level of protection because FEMA establishes protection from a 100-year flood event (one percent annual chance as the minimum level of flood protection for participation in the National Flood Insurance Program. The State encourages cities and counties to achieve higher levels of flood protection for their communities, if feasible. To implement these higher levels of protection, a robust set of criteria for evaluating existing and new flood infrastructure is needed that reflects new advances in geotechnical evaluation and exploration.	Robust and well-accepted design and procedural criteria for cities and counties to make land-use decisions and implement flood improvements.	Develop evaluation, design criteria and procedures to achieve higher levels of protection. Criteria would need to be consistent with established professional standards. The draft Urban Levee Design Criteria developed by DWR is one example of how this management action could be implemented in levees and floodwall improvements.	Development requires low initial costs. However, will increase implementation cost of future flood improvement projects.	Implementation results in additional modifications to the system, which may have positive and/or adverse environmental impacts and may require additional permits.	Would require broad agreement from many stakeholders (cities, counties, public officials, technical experts, etc.) to implement.

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Flood Preparedness, Response, and Recovery	**Coordinate flood response planning and clarify roles and responsibilities related to flood preparedness and emergency response.**	Unclear roles for local (city and county) and State agencies in supporting floodfight operations can impede quick and effective floodfighting during a major flood event. Some agencies and organizations charged with responding in the field during a flood emergency lack the capacity, resources, and interagency coordination necessary to carry out these duties effectively. This is also related to limited conduct or participation in emergency response exercises between flood events. Further, there is infrequent coordination between agencies and limited ability to advance new technologies and science related to levee breaches and floodfighting.	Reduce the consequences of flooding by clarifying roles and responsibilities, improving training and the capacity of emergency response staff, and increasing coordination at all levels of government.	Includes a broad range of tactics at the state and local levels to clarify roles, increase communication, and improve the effectiveness of response to floods. These tactics could include: promoting flood contingency and response planning at local and regional levels; establishing a team to review current regional and local flood emergency procedures, response capacities, and communication capabilities; and convening Maintenance System Specialist committees to review and update Flood Emergency Action Team (FEAT) guidance documents and recommendations. Joint field training exercises and briefings could be facilitated to test and refine response procedures, communications, and logistics, and educate response staff.	Low to medium initial cost. Policy management actions will tend to have a substantially lower capital cost than other management actions that involve physical construction. No significant change in annual costs.	None	High potential for political and public support; institutionally, support also exists, though opinions on how to implement and fund these actions likely differ. Establishing a clear and shared understanding of roles and responsibilities at all government levels may be difficult. Local agency participation may be affected by lack of funding.
Flood Preparedness, Response, and Recovery	**Create Emergency Action Plans to address dam failure**	Dams can fail due to earthquakes, extreme flooding, poor design, unsound construction, inadequate maintenance and age-related problems. Failure can cause catastrophic flooding for downstream areas.	Thorough and consistent emergency action planning to help save lives and reduce property damage in areas that would be affected by dam failure or operation.	An Emergency Action Plan is a formal document that identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The EAP specifies actions the dam owner should take to moderate or alleviate the problems at the dam. It contains procedures and information to assist the dam owner in issuing early warning and notification messages to responsible downstream emergency management authorities of the emergency situation. It also contains inundation maps to show the emergency management authorities of the critical areas for action in case of an emergency.	Low to moderate initial costs. Initial costs are needed to develop emergency action plans. Annual costs consist of updating the emergency action plan on a regular basis.	None.	Political acceptability would likely be high across all levels of government.
Flood Preparedness, Response, and Recovery	**Protect critical infrastructure corridors from flood waters.**	The infrastructure needed to facilitate the flow of resources into, or evacuees out of, a flooded area could be impacted or incapacitated in the event of a flood. Critical infrastructure includes transportation corridors (highways, roadways), electric power supply, railroads, fuel supply lines, telecommunication systems, water supply and wastewater treatment and distribution facilities (aqueducts, pumping stations), hospitals, fire and police stations, and others. This could hinder the orderly and timely evacuation of people and animals of value, impede access by emergency response personnel, and impede restoration of lifeline utility infrastructure (water, power, sewer, telecommunications, etc.).	Facilitate effective emergency response and recovery by protecting critical public infrastructure from flood waters.	Methods for protecting critical infrastructure would vary depending upon size and type of infrastructure. For example, vital transportation corridors could be protected by embankments, flood-control berms, or by elevation above flood waters. Additionally, alternative transportation methods and locations would be identified if primary infrastructure could not be protected. Pumping stations for sewer or water utilities could be flood proofed and equipped with on-site backup power generators. Micro and/or surveillance cameras at critical public assets could be installed. Coordination between, federal, State, local agencies and private utilities would be needed.	High initial costs. Little or no change to annual O&M costs.	Site-specific, but potential substantial permanent impacts to terrestrial and potentially wetland and riparian habitats, including loss of habitat for special-status species. Extensive and complex permitting likely required.	Implement ability would depend on size and type of infrastructure, ownership (federal, state, local, Tribal and private), cost, and potential construction impacts (economic, social)
Flood Preparedness, Response, and Recovery	**Purchase and pre-position flood fighting materials/tools in preparation for a flood event.**	During a flood event, considerable quantities of floodfighting materials (e.g., rock, sandbags, lumber, sheetpiles, other supplies) are often needed with minimal advance notice. Waiting until an event occurs to locate, purchase, and transport materials can slow the response to a flood emergency. During an event, the ability of local agencies to obtain funding is limited because contingency funding is small or nonexistent and banks are reluctant to lend.	Flood fight materials/tools strategically located to improve flood fight response times and reduce emergency costs and damages associated with a lack of timely access to these resources.	Floodfighting materials could be purchased in advance of flood events and stockpiled at materials storage and transfer facilities. These material storage and transfer facilities could be located both locally (for immediate access) and regionally (near barge loading facilities or protected transportation corridors) and stocked based on assumptions related to the magnitude of flood event for which a response is desired, miles of levees supported, etc. Stockpiles could be managed by both State and local agencies to provide access to bulk materials (rock, lumber, sheetpile) and portable materials (sandbags, plastic, etc.). Development of mutual aid agreements that facilitate coordination and sharing of floodfighting materials could also be facilitated to leverage available funding and supply resources.	High initial costs. Majority of costs are upfront capital expenditures. Slight increase in annual costs related to storage and upkeep of floodfighting materials.	None	High capital cost may reduce political and institutional support .
Flood Preparedness, Response, and Recovery	**Participate in the StormReady and TsunamiReady Program**	Several communities have not achieved a basic level of flood or tsunami hazard preparedness. Several communities have no standard to evaluate their level of preparedness and do not know what steps need to be taken to improve their preparedness.	Communities that have achieved a certified level of flood/tsunami preparedness.	StormReady and TsunamiReady are nationwide community preparedness programs under the National Weather Service. The programs encourage communities, universities, counties, and other organizations to take a proactive approach to improving local hazardous weather operations by providing clear-cut guidelines on how to improve their hazardous weather operations including establishing an emergency operations center, warning systems, public education, and emergency response plan. Guidelines for participation in the programs are based on population. A verification visit ensures that applicants meet program guidelines and approval is granted from a local StormReady or TsunamiReady advisory board.	Although there are initial and annual costs for creating the disaster preparedness programs, systems and processes needed to be certified under StormReady or TsunamiReady programs, costs of participation in the programs themselves are minimal.	None.	Participating in the StormReady or TsunamiReady program can help with a community's Community Rating System rating.

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Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Flood Preparedness, Response, and Recovery	**Develop hazardous waste and materials management protocols to identify, contain and remediate potential water quality hazards within floodplains.**	Flooding can impair water quality through the mobilization of hazardous materials or contaminants on floodplains. These materials or contaminants may originate from mines, feed lots, fuel tanks, septic systems, landfills, agricultural runoff, illegal dumping, or other sources. In addition, flooding events following prolonged dry periods may result in, increased water quality impacts from pollutants in the watershed being carried by the runoff. Also, increased runoff during the flood season that temporarily inundates floodways in areas known to have high levels of mercury (or other pollutants) may also impact water quality by increasing methylmercury levels .	Protocols should be developed to manage hazardous waste and materials in the floodplain. Hazardous materials should be identified, contained and remediation conducted, if necessary.	Coordinate with Regional Water Quality Control Boards to develop protocols outlining ways to identify, contain, and remediate potential water quality hazards prior to a flood event. A protocol should be developed to safely use, reuse, and treat sediment contaminated with hazardous materials. Additional research will need to be conducted to identify potential water quality hazards. Containment and remediation will be dependent upon the type and location of hazards found	Policy management actions will have a substantially lower initial cost than other management actions which involve structural modifications. No significant change in annual O&M costs.	Would indirectly contribute to rehabilitation of key physical processes and ecological functions by developing protocols for known highly contaminated areas and cleaning up those areas.	Existing programs to reduce contaminant loading to rivers have publicized this issue, improving its probability of political and institutional acceptance. However, there is potential for political concerns if protocols affect existing industries operating on floodplains.
Flood Preparedness, Response, and Recovery	**Establish standard flood warning systems and procedures.**	While some jurisdictions have established flood warning systems and procedures, other jurisdictions lack them completely. Additionally, a number of different warning systems are currently in varied levels of use at State, federal and local levels. The range of warning/alert systems can cause confusion among the public when responding to a flood emergency, prevent warnings from reaching all members of a community, and prevent interconnectivity between systems in use by different jurisdictions.	Increase public awareness of flood emergencies and increase time for the public to implement home and business emergency actions.	In coordination with existing systems, establish enhanced standard flood warning procedures and terminology. Implement a statewide alert and warning system that is consistent with federal warning protocol and procedures but flexible enough to accommodate the various technologies local jurisdictions already use to warn residents. Such a system and its related implementation steps are described in 2008 and 2009 CalEMA reports. Warning systems include outdoor sirens and/or reverse-911 calling systems. Systems and procedures would be incorporated into local emergency operations plans.	Low capital costs and no significant change in annual costs if implementation does not require physical upgrades or modifications of existing alert systems (such as sirens), or installation of new systems.	None	Likely to be politically acceptable at the State and local levels, particularly since this need has already been documented at the State level. Some smaller local governments may be limited in their funding and institutional capacity to adopt standard flood warning systems and procedures. Additionally, local jurisdictions may understand which systems are most appropriate for their populations and be resistant this action if implementation includes adopting entirely new systems. Other challenges include "warning fatigue" from the public when confronted with another alert system and the likelihood that the public ignores warnings due to past false alarms.
Flood Preparedness, Response, and Recovery	**Improve stream gage network for forecasting purposes.**	Flood forecasting models are limited, in part, by the quantity and quality of available stream gage network data.	Additional stream gages and data sensors installed to improve the quality of flood, tsunami, and reservoir inflow forecasts. Real-time data, its timely availability, and real-time data quantities and quality are all critical data input to the forecasting models and contribute to improving forecasting quality and timeliness.	Install, maintain, and provide priority funding for a comprehensive stream gage network that would improve flood forecasting and monitoring. The network would incorporate and update existing USGS and USACE stream-gaging systems where appropriate. State, federal, local and other public and private entities could collect and share stream gage data. This network would include real-time gaging and dual path telemetry for river stage, rainfall, and temperature data. Network could also be applied for tsunami and seismic sensor data.	Low initial costs. Primary initial costs would consist of installing new gaging stations. Increased annual O&M costs for the stream gage network. Long-term flood system maintenance costs would decrease slightly due to improved operations from flood forecasting. Reservoir operation costs may increase very slightly due to flood forecasting efforts and increased coordination with operators.	Improving the stream gage network would result in minor temporary impacts to riparian and aquatic habitat. Installation of new stream gage stations may require potentially lengthy permitting.	Political acceptability would likely be high across all levels of government. Institutional capacity to improve flood forecasting would reside in the State and Federal levels of government.
Flood Preparedness, Response, and Recovery	**Establish or improve instrumentation for early warning systems for flood facilities**	Warning affected citizens is dependent not only on knowing when a flood peak will occur and how large it will be, but also on knowing the condition of flood infrastructure protecting those citizens. Currently, a system is in place to provide accurate and frequent information on river stage at several reporting gauging stations. However, the system is not set up to provide information on the conditions of flood infrastructure themselves.	Development of a network of telemetered sensors (piezometers and Optical-Time-Domain Reflectometry) that would provide information on seepage pressures and flood infrastructure movement for earthen flood infrastructure. Such information would be extremely useful for coordinating emergency response.	Flood forecasting and warning could be supplemented by a system of telemetered sensors (piezometers and Optical-Time-Domain Reflectometry) that would record and transmit seepage pressure and monitor movement along critical reaches of earthen flood facilities (levees, dikes, etc.). This would provide comprehensive predictions of floods and warning of flood danger from overstressed flood facilities. This system could be installed first in flood facilities protecting high risk areas. Other instrumentation could include remote sensing technology.	Low to moderate initial costs. Primary initial costs would consist of installing new early warning instrumentation. Moderate increase in annual O&M costs related to maintaining instrumentation. But potentially increases efficiency and effectiveness of future O&M, as maintaining agencies will better know which flood facilities are stressed during high water events.	Installing an early warning system could result in temporary or permanent impact to riparian and aquatic habitat depending on site location.	Political acceptability would likely be high across all levels of government. Institutional capacity to improve early warning instrumentation would likely reside in the State and Federal levels of government.
Flood Preparedness, Response, and Recovery	**Integrate environmental compliance and mitigation into the flood fight.**	Flood fighting activities can sometimes lead to environmental violations (under CEQA and/or NEPA) that require extensive mitigation requirements or result in an agency's disqualification for emergency funding reimbursements following an event. Many flood fights occur on or near flood facilities, which means sensitive wetland habitat, riparian areas, or coasts may be damaged by construction, heavy equipment, use of rockpiles, and other activities that occur during flood fighting.	To complete floodfighting activities, when necessary, while minimizing the potential for violating environmental regulations.	Hire or contract environmental compliance specialists who understand the nature of flood fighting and who can help prepare and train crews to minimize impacts to sensitive areas when addressing threats to levee stability. As soon as a flood risk is identified, these staff would be involved in the field to help coordinate the flood fight; as flood threat is assessed, they would also assess potential environmental impacts on existing conditions that could occur in flood fighting. Coordination with resource agencies, FEMA, and flood fighters would be needed.	Increase in initial costs and annual costs. There are additional costs to hire or train an environmental compliance/resource manager. However, these costs should be somewhat offset by no longer needing to hire outside consultants after a flooding event to assist with more extensive mitigation.	Would minimize potential adverse environmental impacts. Would improve efficiency of the permitting process and would decrease mitigation due to environmental violations.	This action would be harder to implement in smaller communities with fewer resources, but would be popular with resource agencies.

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Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Flood Preparedness, Response, and Recovery	**Improve communication and public awareness of emergency response procedures and terminology.**	Public awareness and education prior to a flood emergency directly affects emergency response and recovery efforts. There is a need to educate the public on potential flood risks and how they should respond in a flood emergency. The public's response to any emergency is based on an understanding of the nature of the emergency, the potential hazards, the likely response of emergency services, and knowledge of what individuals and groups should do to increase their chances of survival and recovery.	Increased public awareness/understanding of community flood hazards, emergency response operations, and evacuation procedures before a flood event is imminent.	Effective hazard communication plans would be developed that use standardized evacuation terminology, and these plans would be effectively communicated to the public. Creation of simple, standardized flood threat levels that could be easily displayed on maps and used in public media advisories. Public outreach meetings to notify property owners of flood risks, safety measures, and evacuation routes. Opportunities to integrate this preparedness information into K-12 education curriculum.	Low initial costs. Many existing products are available for use as templates. Increased annual costs possible at the county level. Public information sources and materials, such as websites, maps, and fact sheets, may require ongoing maintenance or updating; and hazard communications plans and related materials would likely need to be reviewed annually to ensure the information is current and correct.	None	Politically and publicly acceptable at the State, regional, and local levels. Some smaller local governments may be limited in their funding and institutional capacity to create hazard communication plans and education outreach without additional assistance.
Flood Preparedness, Response, and Recovery	**Increase financial liquidity of local agencies during flood emergencies.**	Funding available to finance O&M, repairs, and flood fighting varies widely across agencies, and many have a limited ability to raise funds (particularly during emergencies). For example, flood fight responders must often seek assistance or funding for rock, supplies, and technical expertise from the next level of local, State, or federal jurisdiction. Most available State and federal funding sources related to floods are aimed at reducing risk and potential damages in advance of a flood or reimbursing the appropriate jurisdiction for eligible emergency response work—not at helping finance operations during flood fights.	Improved ability of local agencies to quickly raise funds when a flood or other threat to levee stability is imminent.	Several actions could facilitate financial liquidity for local agencies when a flood fight is imminent. One is creation of a public loan guarantee program that would promise to assume maintenance districts' debts from loans obtained to help finance floodflights in the event that districts cannot repay them immediately. This would allow even very small agencies to purchase the resources and expertise needed to help hold back floodwaters. Another option is the creation of an emergency fund.	Low to high initial costs to implement, depending on type and magnitude of program. Annual O&M costs would not change.	None	Potential for broad public support, particularly at local level; would require the identification of sustainable funding, which may require changes to laws and regulations governing the generation of funds for flood system maintenance and repairs. These programs may complicate local efforts to seek FEMA funding assistance after the event, and would also need a repayment structure.
Flood Preparedness, Response, and Recovery	**Improve evacuation planning.**	Not all agencies have prepared local or regional flood-specific evacuation plans. Not all local jurisdictions integrate flood evacuation plans into their overall emergency plans. Not all jurisdictions have distilled flood emergency preparedness and evacuation information into succinct summaries easily accessible and understandable by the public.	Increased coordination across emergency response agencies and greater public awareness of proper evacuation procedures to reduce loss of life during severe flood events.	Coordination between State and local emergency management agencies and officials in developing or updating local flood evacuation plans that identify the range of involved agencies and personnel, notification procedures, public and private transportation options, and evacuation routes/procedures that are easily accessible and understood by the public. These plans should also consider ingress routes for flood fighters while an evacuation is occurring. Important tools in this effort include the 1997 FEAT guidelines for flood emergency operations and ordering evacuations, as well as other mapping tools, vulnerability assessments, and other products from state or regional agencies that could help public safety make decisions on ordering evacuations.	Low initial costs. Policy management actions will tend to have a substantially lower capital cost than other management actions which involve physical construction. No change in annual O&M costs.	None	Likely to be politically acceptable at the State and local levels. Some smaller governments may be limited in their funding and institutional capacity to create evacuation plans without additional assistance.
Flood Preparedness, Response, and Recovery	**Develop post-flood recovery plans to improve the coordination and efficiency of post-flood assistance.**	There is significant variability in the extent and quality of post-flood recovery planning. Where post-flood recovery plans exist, these plans are generally driven by the eligibility requirements of the Stafford Act. Debris removal and economic recovery operations are often conducted well after floods, but are often limited to the extent that they are eligible for limited State disaster assistance funds and/or federal reimbursement and assistance through FEMA, USDA, etc. Coordinating post-flood recovery activities can be difficult because the range of agencies with legal or voluntary responsibilities for disaster recovery often cross jurisdictions and levels of government.	Development of simple, direct, integrated plans of action for post-flood recovery to reduce confusion, clarify roles and responsibilities, and facilitate expedited disaster recovery	Identify all responsible people, agencies, or organizations with disaster recovery roles and responsibilities; detail relevant recovery activities, including levee repair, flood water evacuation, and property and infrastructure rehabilitation; establish or describe timelines and protocols for accomplishing recovery activities; and identify all State, federal, and non-governmental sources of potential disaster assistance funding, both general and flood-specific.	Low initial costs. Policy management actions tend to have a substantially lower capital cost than other management actions which involve physical construction. Capital investments include funding for multiagency, multijurisdictional planning and development of post-flood recovery plans. Increased post-flood recovery planning prior to flood events reduces maintenance and repair costs for maintaining agencies.	None	Politically and publicly acceptable at State, regional, and local levels. Institutionally, there may be difficulties with developing a single plan for an entire region (unless there is resolution of inconsistencies related to agency responsibilities in various regions). Some smaller agencies may be limited in their funding and institutional capacity to develop post-flood recovery plans.
Flood Preparedness, Response, and Recovery	**Streamline the post-flood permitting process for flood system repairs.**	Obtaining permits for post-flood system repairs involves coordination with multiple agencies that can exceed the staff resources and budgets of smaller maintaining agencies. With multiple permits required for most maintenance and mitigation activities, and no central location for coordinating the process, obtaining the necessary permits often takes longer than the actual repairs.	Reduced costs and time needed to complete system repairs can reduce future flood risk.	The process of obtaining permits for the repair of damaged structures would be streamlined and consolidated, to save time and money. Coordination with federal and State agencies involved in the permitting process to develop a consistent permitting program that is easy to understand and comply with at the local level. Permit applications submitted to Federal and State agencies through the permitting program would have priority in the review process, allowing permits to be issued in a timely manner so that repairs of damaged infrastructure could begin shortly after a flood event.	Medium initial costs. While policy management actions tend to have a substantially lower capital cost than other management actions which involve physical construction, significant interagency coordination (on the State and federal levels) is required to streamline the permitting process for flood-system repairs. Streamlining the permitting process should reduce annual costs for maintaining agencies.	None	Streamlining the permitting process should be very popular with maintaining agencies because it would reduce the time and funding required to obtain permits. Likely to be politically and publicly acceptable. State and federal permitting agencies may oppose this effort if it appears to render permit requirements less stringent or infringe upon their authority or jurisdiction.

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Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Flood Preparedness, Response, and Recovery	**Encourage multi-jurisdictional and regional partnerships on flood planning and improve agency coordination on flood management activities, including operation and maintenance, repair, and restoration.**	Flood management is often complicated by the large number of agencies and entities involved, and their complex jurisdictional roles and responsibilities. Overlapping jurisdictions across various federal and State agencies involved in flood management can lead to inconsistent policies and regulations, conflicting guidance, or inefficiencies in planning and implementing projects. Coordinating activities within this fragmented jurisdictional landscape can be challenging, particularly for local entities with limited resources.	The benefits of improved coordination could include streamlined permitting and approval processes; more efficient and cost-effective routine maintenance and repairs; more successful and sustainable environmental mitigation through regional coordination with conservation efforts; better leveraging of available funding sources; and flood management projects that provide multiple, mutual benefits.	Coordination between agencies and responsible parties could take many forms, including roundtable discussions, oversight committees, interagency liaisons, repurposed agencies, Joint Power Authorities, Councils of Governments, or new entities. Improving coordination and cooperation might involve establishment of a new institutional framework, such as a system-wide, continuous, integrated group of responsible entities/agencies to oversee and coordinate flood protection, operations and maintenance. Another method would be to establish a single entity or resource with oversight responsibilities to streamline and provide guidelines for all planning, construction, maintenance, repair and restoration activities associated with flood management. With respect to emergency planning and response, a multi-agency coordination system could be developed to improve regional coordination, incident prioritization, and resource management in a major flood.	Low initial costs compared with structural measures. Potential to decrease annual O&M costs through streamlining and improving regional coordination	No direct effects; however, improved coordination could foster integration of mitigation, restoration, and conservation activities across multiple agencies and jurisdictions, resulting in more successful rehabilitation of ecosystem functions.	May be difficult to sustain coordination over the long-term; individual agencies may be unwilling or unable to participate due to cost or governance structure
Flood Preparedness, Response, and Recovery	**Clarify flood management responsibilities for local, regional, State, and federal agencies.**	There often lacks a consistent understanding of flood management responsibilities across local, regional, State and federal agencies regarding operations and maintenance, repair, improvements, inspection, and other activities . Although roles and responsibilities are specified through a combination of existing law, regulations, and agreements, disagreements frequently exist among federal, State, and local agencies. Confusion occurs for various reasons such as dated regulations, incomplete records, precedence established through historical practices, lack of funding, lack of consistent enforcement, and conflicting management policies.	Improved understanding of flood management roles and responsibilities across local, regional, State and federal agencies	In order to clarify limits of responsibility, State, Federal and local agencies could identify responsibilities requiring clarification, refer to existing guidance, regulations and agreements, and develop a common understanding of these issues.	Low initial costs. Measures put in place consist of policies, plans, improved tools, and does not involve physical construction. This action would not impact the annual cost of O&M, but could impact the allocation of cost/responsibility.	None.	This management action has high level of support from maintaining agencies.
Policy and Regulations	**Encourage compatible land uses with flood management system and floodplain function.**	Urbanization in floodplains increases the potential for flood damage to homes, businesses, and communities. Land use decisions made at the local level often allow development in floodplains and create situations that are incompatible with flood management systems and existing flood protection for the area. With a limited understanding of the beneficial functions of floodplains, some assert that floodplain management decisions have often been made outside of the context of watershed-level planning and without adequate consideration for natural and beneficial floodplain functions.	There is an opportunity to better plan development that is more compatible with flood management by coordinating land-use decisions. Decisions made at the local level that provide flood protection can also benefit the community with areas of open space, parkways, trails, or habitat lands.	Delineate appropriate and allowable urban and rural land uses within floodplains and identify ways, where feasible, that flood prone lands can serve multiple uses (i.e., groundwater recharge, recreation, or habitat). Define criteria for development in flood-prone areas, promote Low Impact Development (LID) techniques, and conduct research on compatible cropping or agricultural practices for certain agricultural areas with high flood risk. In coastal areas, this could include defining coastal construction setback lines and zones that restrict construction close to the shoreline.	Low initial costs. Measures include policies, best management plans, financial incentive programs, educational programs, and does not involve physical construction. Would likely lead to decrease in annual O&M costs.	Could result in rehabilitation of key physical processes and ecosystem functions by identifying and setting aside areas where rehabilitation would be most beneficial for habitats and flood management and restricting development there.	Implementation is compatible with State policy for preserving land use authority within local jurisdictions. It is also compatible with current legislation requirements in the Central Valley to address flood hazards in local land use planning. Cities and counties located in floodplains may resist restrictions that limit their development.
Policy and Regulations	**Designate lands for dedicated flood flows**	Not all jurisdictions have lands designated for dedicated flood flows. Where they do exist, they are often outdated and do not reflect recent changes in hydraulic or hydrologic conditions.	Additional floodways could be designated to ensure consistency with the current understanding of hydraulic and hydrologic conditions.	Designated floodways are channels of the stream and that portion of the adjoining floodplain reasonably required to provide for the passage of a design flood. Designated floodways help improve a community's level of protection. This management action would update the State's designated floodway program or update or create other similar local designations. This effort would be integrated with the recent hydrologic and hydraulic modeling results.	Low initial costs. Non-structural management actions will tend to have a substantially lower capital cost than other management actions that involve physical construction. No change in annual O&M and repair costs.	Similar to adoption of a land use general plan, if changes to policy or regulations would result in project implementation (e.g., physical impacts), CEQA compliance would be required. Permitting may be required if policy is implemented and if there are impacts to regulated resources.	May eliminate opportunity for urban development within boundaries of new floodways. However, could provide opportunities for other development, both within the new designated floodway (agricultural, recreational, and habitat uses) and also in neighboring communities that might have the benefit of improved flood protection.
Policy and Regulations	**Develop local flood management plan updates**	The most recent and applicable data is not always available or used for updates to local flood management and land use planning documents, resulting in outdated planning strategy and reduced benefits. Many flood related regulations and planning are associated with a defined level of protection or an event of certain return frequency, which is subject to change based on hydrological record. Some local agencies are limited in their capacity to update local flood management plans and may require institutional and technical support.	State and local agencies would manage floodplains more proactively and adaptively and would have access to the most recent hydrologic, climate, physical and biological conditions, policies and land use data in order to adequately update planning documents for land use and flood management.	This would consist of General Plan updates, local flood management plan updates, regional general permitting, NCCPs, HCPs and other planning documents and enactment of local zoning amendments to increase level of protection. New data developed by local agencies for flood management planning purposes (i.e. new hydraulic models) would be integrated into planning documents when updated.	Low initial costs. Measures include policies, plans, improved tools, and does not involve physical construction. No impact on annual O&M costs in the short-term. Potential decrease in long-term annual O&M costs.	Dependent upon content of local plans.	Overall, improved land use management would be favorable to overall general public, government agencies, but some resistance by cities/counties that depend on tax base, and development industry.

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Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Policy and Regulations	**Provide information and data to assist local communities in planning and evaluating land use proposals on alluvial fan areas**	Practices utilized to address alluvial fan conditions generally lack consistency in California. Local governments that plan for and evaluate future development on alluvial fans sometimes have an insufficient understanding about alluvial fan flooding.	Increased awareness among local communities to plan and evaluate land use proposals in alluvial fan areas	The State, local agencies and universities would identify a process to create and maintain a web-based portal that allows interested parties to access the pre-project screening and flood management tools and data for hazard and resource evaluation for special alluvial fan area being planned or proposed for development.	Medium initial costs needed for coordination and data gathering and outreach. Low annual costs.	None	Would require significant coordination across local agencies. Significant educational outreach would need to be conducted to promote the web-based portal
Policy and Regulations	**Managed retreat**	In some areas, coastal flood risk is so high and shoreline protection efforts and/or their repeated maintenance would be too costly and ultimately ineffective at preventing further erosion.	Reduced consequences of coastal flooding	Allows the shoreline to advance inward unimpeded. As the shore erodes, buildings and other infrastructure are either demolished or relocated inland. A managed retreat approach typically involves establishing thresholds to trigger demolition or relocation of structures threatened by erosion. The term managed retreat has been used to describe policies ranging from complete removal of all shore protection structures to simply not allowing new structures to be built.	Initial costs are usually needed to relocate and demolish structures that will be flooded. Little to no annual O&M costs.	Maintains natural shoreline dynamics and enables shoreline habitats to migrate inland as the shoreline erodes	Can be politically difficult to implement, especially where significant development has already occurred. May cause depreciation of shorefront property values. Gaining widespread political support is critical for success.
Policy and Regulations	**Use Building Code amendments to reduce consequence of flooding.**	Mandatory building provisions related to flood protection that are required for the Special Flood Hazard Area (100-year floodplain) are provided by local Flood Management Ordinances. These ordinances address flood protection mainly through elevation of structures.	Additional mandatory Building Code provisions to protect residents from death and severe injury during floods, and increase the resilience of the building to reduce damage and required time for recovery.	Jurisdictions can update their building codes to increase flood resilience. Adapt building code as appropriate to California hazards and vulnerabilities. Building code amendments can include various structural improvements for public safety reasons and for dry and wet proofing tactics to reduce overall consequence of flooding. Due to the various types of buildings and business sectors associated with each building occupancy categories, the requirements may have to be customized for individual occupancy, in coordination with relevant state regulatory agencies and major industrial and professional groups. As with most building code amendments, the proposed code amendment could apply to new construction and existing buildings that require significant improvement and upgrade.	Relative low initial costs for implementing building code changes. The additional cost to implement the new codes, such as the added costs of building officials reviewing plans and permitting applications, could be recovered through additional fee requirements or development agreements. The additional cost to developers for meeting the new code requirements would be recovered through additional fees added to the lease or purchase price of the property. There may be an increase in annual costs associated with increased enforcement, inspection, and potential flood drills, subject to the actual code proposal.	If changes to policy or regulations would result in project implementation (e.g., physical impacts) CEQA compliance would be required.	Significant agency and interest group coordination is required because of the various occupancy groups that may be affected by the proposed code amendment, and customization is required. The application of building code amendments is limited to new constructions and existing buildings with significant improvement and upgrade; therefore, it would not provide a uniform improvement on building safety and resilience during floods.
Permitting	**Develop regional and corridor conservation plans, or expand existing regional conservation plans (such as regional Habitat Conservation Plans and Natural Community Conservation Plans) to provide a more efficient and effective regulatory approval process for flood projects.**	Habitat and ecosystem planning is conducted in piecemeal, fragmented fashion in many areas. Multiple regulatory agencies are responsible for ensuring the protection or mitigation of environmental resources impacted by flood management activities. Limited coordination and shared vision results in a regulatory approval process that adds complexity and scheduling challenges to flood project approvals. It also results in fragmented conservation projects that may have limited viability in terms of long-term biological success.	High-quality regional and river-corridor conservation plans that both improve the success rate of flood project regulatory approval and providing improved multi-species habitat that is viable for the long-term.	Develop plans such that they provide measurable biological objectives for targeted resources, incorporate adaptive management approaches, fund long-term habitat management and monitoring, and provides the public with the opportunity to assess, review, and critique plans as they are being developed.	Medium to high initial costs. Plans such as HCPs and NCCPs require adequate funding to develop. Implementation of the plans will have varying capital costs. Changes to annual costs.	Increased regional collaboration among habitat and ecosystem planning and mitigation would result in rehabilitation of ecosystem functions by concentrating mitigation in larger areas, and by selecting more suitable lands for mitigation than is possible with piecemeal mitigation. Would result in improved and streamlined permitting for future projects. Impacts associated with flood system O&M could be reduced because O&M would be better facilitated and mitigation better coordinated.	California currently already has over 30 regional conservation plans in varying stages, with some plans in the implementation phase for over 10 years. Corridor management plans are already under development, and they are being viewed as valuable approaches for meeting multiple flood management goals on specific reaches. Institutional, legal, and funding challenges exist.
Permitting	**Develop regional advanced mitigation strategies and promote networks of both public and private mitigation banks to meet the needs of flood and other public infrastructure projects.**	Some flood management projects require offsite mitigation to compensate for habitat losses. Identifying suitable off-site locations is often left to the last phase of flood projects, as it becomes more evident about the extent and nature of the expected impact. Regulatory agencies need to approve these off-site locations, and negotiations can delay overall flood project approvals. Second, a temporal loss of habitat occurs between the time when the flood project removes habitat and when compensatory habitat is restored to pre-project levels. Third, off-site locations that are comparable in area to the impact are often too small and isolated to have long-term viability and often require high maintenance costs. Lastly, generating funding sources for mitigation early in the planning stages is an obstacle.	High quality regional advance mitigation strategies and networks of mitigation banks that meet the needs of flood and other public infrastructure projects.	Develop supporting policies, sustainable funding sources and partnerships with regulatory agencies for planning and implementation of comprehensive regional advance mitigation banks.	High initial cost. Establishment of mitigation banks requires acquisition of land, permitting, restoration, and funding for long-term management and monitoring. Regional collaboration for advance mitigation banks is likely to decrease overall costs of regulatory compliance and mitigation for O&M and repair activities. Potential exists to leverage private conservation funds.	Implementation and coordination on regional advance mitigation planning would result in rehabilitation of ecosystem functions by concentrating mitigation in larger areas, by implementing mitigation in advance of impacts, and by selecting more suitable lands for mitigation than is possible with piecemeal mitigation. Improved and streamlined permitting for future infrastructure projects. Banking has a complex set of permitting requirements and it will take extensive work to create credits that can be used for flood projects.	There is high interest in developing regional advance mitigation banks from infrastructure agencies, resource agencies, and conservation organizations. Private mitigation banks already exist and regulatory agencies have developed standard approval processes for establishing these banks. Institutional, legal, funding, and community relations challenges exist.

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Flood Management Action Category	Management Action	Problem Addressed	Desired Outcome	Methodology	Cost Considerations	Environmental Considerations	Social Considerations
Permitting	**Develop proactive integrated regulatory compliance strategies that streamlines permitting activities.**	Numerous permits are required to conduct routine maintenance, restoration, enhancement, and other activities. Challenges associated with permitting include the costs associated with documentation and mitigation, length of the process, restrictive conditions, conflicting state and federal priorities, limited construction work windows, uncertainty regarding which permits are required for routine maintenance, and limited coordination among the various entities issuing permits. Many maintaining agencies have expressed concern over the amount of funds dedicated to obtaining permits to perform required maintenance. This situation creates regulatory uncertainty for both the State, maintaining agencies and regulatory agencies.	Implement a regulatory compliance strategy (such as the DWR Small Erosion Repair Program), that standardizes and streamlines the permitting process (timeliness and efficiency), reduces costs, and promotes regional efforts that support more successful mitigation to improve public safety, reliable water supply, and ecosystem function.	Identify where environmental clearance and permitting processes can be made more efficient while still meeting state and federal safety standards and following state and federal environmental protection procedures. Below are some options: 1. Increasing the duration over which permits are valid to reduce costs and promote proactive maintenance. 2. Establishing an interagency permitting office or clearinghouse to improve the review, frequency of inspection, and enforcement of encroachment permits and permit violations 3. Providing habitat restoration above and beyond what is necessary for project impacts could assist in streamlining future mitigation needs as would implementing a Regional Advanced Mitigation Program. Establishment of a consistent, widely-recognized definition of "routine maintenance" and the activities associated with maintenance. Knowing how routine maintenance actions can avoid and minimize impacts.	Low initial cost. Policy actions will tend to have a substantially lower capital cost than actions involving physical construction. If land is purchased for mitigation, initial costs could be high. A streamlined permitting process has the potential to reduce long-term annual maintenance and repair costs by allowing more swift repairs before sites become larger.	Implementing proactive compliance strategies can address larger scale environmental impact avoidance and opportunities to enhance the environment. It could allow for rehabilitation of ecological functions, by implementing mitigation in larger consolidated areas, in advance of impacts, and in more suitable areas than with piecemeal mitigation. Impacts associated with flood system O&M could be reduced because O&M would be better facilitated and mitigation better coordinated.	Initial development of a new permitting strategy would require intense coordination and commitment by multiple agencies; however, once streamlined and/or programmatic permitting mechanisms are established, flood system maintenance activities would be more timely and cost-effective for all parties involved. A streamlined process is likely to preserve maintenance funds for maintenance, not redirecting them for permitting costs. The net result is cheaper, more reliable and better maintained levee.
Permitting	**Increase understanding of environmental permits.**	Applying for and obtaining environmental permits for construction and O&M activities can be a complex and arduous process.	Greater understanding of what permits are required, what the agencies need to issue these permits, and the timelines associated with these permits.	Provide technical assistance and education on required environmental permits for construction and O&M activities. A permit workbook would be developed and distributed in training workshops that would include a description of the relevant permits, permit applications and permitting guidance for each of the regulatory agencies. Applicable laws and regulations include, but are not limited to, Section 404 of the Clean Water Act (CWA), Section 10 of the Rivers and Harbors Act, Section 401 of the CWA, Section 1602 and 1603 of the California Department of Fish and Game Code, Endangered Species Act, California Endangered Species Act, California Environmental Quality Act, and the Section 106 of the National Historic Preservation Act.	Low initial costs compared with structural measures. Would likely have no significant change on annual costs to operate/maintain/repair.	Technical assistance and education on environmental permits could help facilitate the environmental permitting process and indirectly have a positive impact on physical processes and ecological functions.	Technical assistance and education on environmental permits is anticipated to be well received and therefore, the likelihood of implementation is high.
Permitting	**Corridor Management Strategy (CMS)**	Many flood infrastructure facilities encompass critical habitat and migration corridors for many listed and endangered species. Flood infrastructure in many areas is nearing the end of its design life. Many challenges exist to obtaining permits and clearances for repair, replacement, and ongoing maintenance. A new approach in managing flood control infrastructure is required if today's needs are to be served.	An effective and sustainable water management system through integration of public safety, water supply, and ecosystem function - managing flood infrastructure as a system and in a manner that addresses the needs of all three.	Identify discrete corridors; assess existing channel habitat and geomorphology and identify how the channel could be better managed in terms of public safety, water supply and ecological function; and develop long-term management plans for these corridors (including a prioritized list of needed repairs and/or new construction; areas identified for ecosystem restoration opportunities; a long-term routine maintenance plan; permits and clearances for nearer-term repair/construction and routine maintenance (long-term); performance measures for public safety, water supply and the ecosystem; a monitoring and reporting plan evaluating success in meeting performance measures); and an adaptive management plan. Modifications to the corridor and ongoing maintenance will be designed to manage for flow (peak for public safety, and non-peak for reliability in water supply) and improved ecosystem function. Project proponents, along with State, federal and local permitting agencies, local maintaining agencies, and representatives from local communities served by the corridor, should all be a part of the process when Corridor Management Plans are developed, so the critical needs of all entities either responsible for, or served by, the corridor can be considered in the process and appropriate solutions designed to address the various needs, system performance criteria and permitting requirements.	Medium initial costs. Corridor Management Strategy plans require adequate funding to develop. Implementation of the plans, which constitute other management actions, will have varying capital costs depending on the extent of real estate and construction needs. Annual O&M costs would decrease. Long-term management plans for maintenance can allow for more swift repairs before sites become larger, which is less costly, and better for the environment and public safety.	Use of long-term plans could allow for mitigation that allows for enhancement of corridors for improved ecological functions by implementing mitigation in larger consolidated areas, in advance of impacts, and in more suitable areas than with piecemeal mitigation.	Corridor Management Strategies are being developed and they are being viewed as valuable approaches for providing multiple benefits on specific reaches including flood management and improved ecosystem function.
Permitting	**Establish memoranda of understanding (MOUs) and/or management agreements between agencies to integrate the needs to be served by flood control systems.**	Some flood infrastructure is located near critical habitat and migration corridors for many listed and endangered species. There are many challenges to implementing mitigation and restoration activities in support of flood infrastructure. Conducting ongoing maintenance is also a costly, complicated and lengthy process. There are few interagency collaborations and partnerships that leverage the strengths of multiple agencies/organizations to achieve successful mitigation/restoration, ongoing maintenance, and the achievement of multiple benefits.	An efficient, collaborative interagency approach that acknowledges the prime purpose of flood management is public safety, while providing the appropriate assurances and process to allow for mitigation and restoration efforts managed in concurrence with ongoing operations and maintenance for flood management and water supply.	Use approaches and interagency memoranda of understanding (MOUs) and management agreements, such as those used for the Yolo Basin Wetland Project, to provide the assurances and process needed to enable mitigation and restoration opportunities to be realized, while providing for effective management for water supply, flood control and habitat.	Low initial costs compared with structural measures. Potential to decrease annual O&M costs through streamlining and improving regional coordination.	No direct effects on environmental conditions. However, improved coordination could foster integration of mitigation, restoration, and conservation activities across multiple agencies and jurisdictions, resulting in more successful rehabilitation of ecosystem functions (consolidating mitigation efforts within regions, implementing mitigation in advance of impacts, and selecting more suitable lands for mitigation). Could result in improved and streamlined permitting processes, including long-term agreements and authorizations for future efforts.	May be difficult to initially develop the MOU's. Requires up front time and cost for pre-planning and to execution of the agreements. Institutional, legal, and funding challenges exist.

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Finance and Revenue	**Maximize funding for flood management projects by leveraging Federal funding.**	Current federal, State, and local funding mechanisms are not adequate to sustain effective flood management.	Maximize available funding for flood management projects.	Projects could be planned and developed specifically to leverage funding from multiple federal sources, including FEMA, NFIP, Natural Resource Conservation Service (NRCS), USFWS, and USACE. This might include development of multi-benefit projects that leverage funding for a variety of federal project purposes (flood risk reduction, environmental restoration, hazard mitigation, water supply, water quality), or development of projects that incorporate both structural and non-structural actions addressing flood risk reduction and mitigation once flooding occurs.	Substantial local funding may be needed to meet cost-share requirements. Meeting federal standards may require changes to project design. Annual O&M costs would not change.	None	Potential for broad public support; may require changes to laws or regulations at a Federal level (cost sharing and/or appropriations); may require new local, State, or Federal programs
Finance and Revenue	**Leverage funding from multiple projects to improve cost-effectiveness and efficiency of flood management projects.**	There are often numerous projects occurring simultaneously in the same region, all of which conduct planning, design, permitting, and mitigation activities independent of each other. This could result in duplicate efforts and the potential for missed opportunities to provide mutual benefits.	Improve the cost effectiveness and financial feasibility of individual flood management projects by consolidating projects on a regional or systemwide level. Consolidating and coordinating planning and design activities could also highlight opportunities to provide mutual benefits or multiple benefits beyond those planned as part of individual projects, improve the effectiveness and sustainability of mitigation activities, and leverage funding and implementation support from multiple sources.	Align new multi-benefit project with other existing or planned projects (such as roads or highways) to leverage funding from multiple agencies and jurisdictions, increase construction and maintenance efficiency, combine mitigation efforts, and accomplish multiple objectives.	Low initial cost to implement. Annual O&M costs could be less with integrated projects as opposed to multiple single-purpose projects pursued in isolation.	Key physical processes and ecosystem functions could be rehabilitated by combining funding requests of ecosystem restoration projects with flood management projects, increasing the likelihood for funding of both.	Potential for broad public support; would require increased coordination at State, federal, and regional levels. Institutional, legal, and funding challenges exist.
Finance and Revenue	**Establish a methodology for evaluating benefits and costs on a systemwide basis to support economic justification for projects in all community settings.**	Existing criteria for determining cost-benefit analysis of projects is very rigid. Some benefits that do not have an obvious monetary value may be excluded. In addition, if only the benefits to the immediate project area are determined, and not the benefits to the system as a whole, a project may underestimate benefits.	Cost-benefit analysis would show benefits to both the immediate area and systemwide. The value of benefits that don't have an obvious monetary value would be developed.	Develop a new set of criteria that is more inclusive and looks at all benefits for both the immediate area and the system as a whole. Methods to determine value of benefits that do not have an obvious monetary value should be developed.	Moderate initial costs. Criteria need to be developed and training needs to take place before cost-benefit analysis can begin. No direct impact on annual costs.	No direct impacts	This action would have a lot of support from communities that feel like benefits for their projects have traditionally been undervalued.

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		Slow-Rise	Flash	Debris Flow	Alluvial Fan	Coastal	Tsunami	Engineered Structure Failure	Stormwater Management	Water Supply	Groundwater Recharge	Water Management Flexibility	Ecosystem Habitat	Invasive Species Management	Restore Natural Floodplain Processes	Erosion/Sediment Management	Fisheries	Recreation or Open Space	Hydropower	Navigation	Water Quality	Improve Agency Coordination	Conveyance	System Reoperation	Surface Storage	Conjunctive Management and Groundwater Recharge	Recharge Area Protection	Ecosystem Restoration	Pollution Prevention	Land Use Planning and Management	Agricultural Land Stewardship	Watershed Management	Forest Management	Urban Runoff Management	Sediment Management	Water-Dependent Recreation	Outreach and Education
Floodplain Conservation and Restoration	**Manage runoff through watershed management.**	X	X						X	X	X		X			X		X					x			x	x	x		x		x				
Floodplain Conservation and Restoration	**Remove unnatural hard points within and along channels.**	X	X										X			X		X					x					x						x		
Floodplain Conservation and Restoration	**Operate reservoirs with flood reservation space to more closely approximate natural flow regimes.**	X	X										X		X	X	X	X						x	x			x						x		
Floodplain Conservation and Restoration	**Set back levees to connect rivers to floodplains.**	X	X							X	X	X	X		X	X	X	X			X		x			x	x	x	x						x	x	
Floodplain Conservation and Restoration	**Restore channel alignment (i.e. conduct de-channelization).**	X	X							X	X		X		X	X	X	X			X		x			x	x	x	x						x	x	

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Floodplain Conservation and Restoration	**Encourage natural physical geomorphic processes including channel migration and sediment transport.**	X	X	X						X	X		X		X	X	X	X			X		x			x	x	x	x	x	x	x	x	x	x	
Floodplain Conservation and Restoration	**Remove and/or deauthorize disconnected, redundant, obsolete, and nonfunctional facilities**	X	X	X	X	X	X	X	X				X		X	X		X																x		
Floodplain Conservation and Restoration	**Remove barriers to fish passage.**	X	X							X			X				X	X										x							x	
Floodplain Conservation and Restoration	**Improve the quality, quantity, and connectivity of wetland, riparian, woodland, grassland, and other native habitat communities.**	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X			X		x					x	x	x		x	x	x	x	x	
Floodplain Conservation and Restoration	**Create a strategic pooled money account that provides funds for land stewardship activities at current and future flood-related mitigation areas over perpetuity.**	X	X	X	X	X	X	X	X				X		X			X										x		x	x	x	x	x		x	

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Floodplain Conservation and Restoration	**Reduce the incidence of invasive species in flood management systems.**	X	X	X	X	X	X	X	X				X	X	X	X	X	X					x					x			x	x	x	x	x	
Land Use and Floodplain Management	**Reduce flood damages through acquisitions, easements, and private conservation programs.**	X	X	X	X	X	X	X	X	X	X		X		X	X		X					x			x	x	x		x	x	x	x		x	x	
Land Use and Floodplain Management	**Use floodproofing measures (such as wet or dry floodproofing, raising, or relocating structures)**	X	X	X	X	X	X	X	X																					x				x			
Land Use and Floodplain Management	**Develop mandatory flood insurance programs that are more consistent with the area's risk of flooding.**	X	X	X	X	X	X	X	X																												x
Land Use and Floodplain Management	**Develop a State program and framework to reduce or eliminate subsidies for repetitive loss properties in floodprone areas.**	X	X	X	X	X	X	X	X																												x
Land Use and Floodplain Management	**Coordinate and streamline floodplain mapping to improve consistency of floodplain delineation and assessment of flood risk**	X	X	X	X	X	X	X																													x

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Land Use and Floodplain Management	**Increase flood risk awareness through outreach.**	X	X	X	X	X	X	X	X																											x
Land Use and Floodplain Management	**Increase awareness of and participation in the Community Rating System insurance-rate adjusting program.**	X	X	X	X	X	X	X																												x
Land Use and Floodplain Management	**Improve awareness of floodplain function through outreach and education.**	X	X	X	X	X	X	X	X		X		X		X			X	X		X					x	x	x	x	x	x	x	x	x	x	x
Land Use and Floodplain Management	**Examine potential interaction between natural hazards in assessing a community's flood risk**				X																								x							x
Land Use and Floodplain Management	**Manage municipal stormwater to provide regional or systemwide flood benefits.**	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X			X					x	x	x	x	x						
Flood Infrastructure	**Construct new levees or floodwalls to provide flood protection to additional areas potentially affected by flooding**	X	X			X	X	X										X					x												x	

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Flood Infrastructure	Raise levees to improve flood system performance.	X	X			X	X	X										X					x												x	
Flood Infrastructure	Construct setback levees.	X	X		X			X		X	X		X		X	X	X	X					x			x	x	x							x	x	
Flood Infrastructure	Construct ring levees.	X	X			X	X	X																													
Flood Infrastructure	Improve structural performance and resilience of existing flood facilities.	X	X	X	X	X	X	X								X							x														
Flood Infrastructure	Construct flood infrastructure that would redirect floodwaters, subdivide larger basins, or isolate inundation	X	X	X	X	X	X	X	X							X							x														
Flood Infrastructure	Improve conveyance by addressing flow constrictions.	X	X							X			X		X	X	X	X		X			x					x							x		
Flood Infrastructure	Increase capacity of existing bypasses.	X	X										X		X	X	X	X					x					x							x	x	

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Flood Infrastructure	**Construct new bypasses to improve flood system performance.**	X	X							X	X		X		X	X	X	X					x			x	x	x							x	x	
Flood Infrastructure	**Construct armoring structures such as sea walls, sea dikes, revetments and bulkheads.**					X	X									X																			x		
Flood Infrastructure	**Construct storm surge barrier with movable locks or gates**					X						X	X		X	X				X								x							x		
Flood Infrastructure	**Construct shoreline stabilization, such as breakwaters, groins, sills and natural and artificial reefs**					X							X			X		X										x							x	x	
Flood Infrastructure	**Beach nourishment**					X							X		X	X		X										x							x	x	
Flood Infrastructure	**Nourishment of natural or artificial dunes**					X							X		X	X		X										x							x	x	
Flood Infrastructure	**Construct debris basins**			X	X				X	X						X					X		x						x							x		

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Flood Infrastructure	Preserve active washes				X					X	X		X		X	X		X			X		x			x	x	x	x						x	x	
Flood Infrastructure	Construct closure structures.	X	X			X	X	X																														
Flood Infrastructure	Modify existing weirs, overflows, or relief structures to improve flood system performance.	X	X							X					X	X	X											x							x			
Floodplain and Reservoir Storage and Operations	Construct new or enlarge existing transitory floodplain storage.	X	X							X	X	X	X		X			X						x	x	x	x	x								x		
Floodplain and Reservoir Storage and Operations	Increase on-stream flood storage capacity by building new storage facilities or updating, modifying or replacing existing flood storage facilities.	X	X					X		X		X					X	X	X						x	x			x							x		
Floodplain and Reservoir Storage and Operations	Restore storage in existing reservoirs via dredging activities.	X	X							X		X				X	X	X	X						x	x			x							x	x	

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Floodplain and Reservoir Storage and Operations	**Increase flood control allocation by expanding existing, on-stream reservoirs.**	X	X							X		X					X	X	X					x	x			x							x	
Floodplain and Reservoir Storage and Operations	**Increase foothill and upper watershed storage.**	X	X							X		X					X	X	X					x	x			x				x			x	
Floodplain and Reservoir Storage and Operations	**Increase flood control allocation by using spillway surcharge.**	X	X							X		X					X	X	X					x	x			x							x	
Floodplain and Reservoir Storage and Operations	**Increase flood control allocation by expanding existing or building new off-stream storage.**	X	X							X		X					X	X	X					x	x			x							x	
Floodplain and Reservoir Storage and Operations	**Establish partnerships to coordinate flood management structure operations.**	X	X							X		X						X	X			X		x	x			x							x	
Floodplain and Reservoir Storage and Operations	**Increase flood management flexibility through modifications to the magnitude/timing of flood reservations in reservoirs.**	X	X							X		X	X		X	X	X	X	X		X			x	x			x							x	

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Floodplain and Reservoir Storage and Operations	Increase flood management flexibility through modifications to objective release schedules at flood management reservoirs.	X	X							X		X	X			X	X	X	X					x	x			x						x	x	
Floodplain and Reservoir Storage and Operations	Increase flood management flexibility by implementing conjunctive use programs at flood management reservoirs.	X	X							X	X	X	X					X	X					x	x	x	x	x							x	
Floodplain and Reservoir Storage and Operations	Implement advanced weather forecast-based operations to increase reservoir management flexibility.	X	X							X		X	X					X	X			X		x	x			x							x	
O&M	Restore channel form and function to improve O&M and facilitate flood damage reduction.	X	X										X		X	X							x					x						x		
O&M	Perform clearing and snagging within channels.	X	X													X							x											x		

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O&M	Perform dredging to remove sediment from channels.	X	X													X				X			x												x			
O&M	Reuse excess materials derived from channel maintenance.	X	X										X			X							x												x			
O&M	Develop regional channel vegetation management plans.	X	X										X		X	X		X					x					x											
O&M	Develop encroachment management programs.	X	X					X														X	x																
O&M	Provide administration and oversight of levee penetrations.	X	X					X														X																	
O&M	Improve interior drainage.	X	X						X														x																

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O&M	Protect vulnerable levees and banks through stabilization and erosion repairs.	X	X			X		X					X			X																		x		
O&M	Revise O&M manuals to be consistent with new and current policies that support multi-benefits of the flood system.	X	X							X	X	X	X		X	X		X								x	x	x							x	x	
O&M	Effectively maintain, operate, and rehabilitate closure structures.	X	X																																		
O&M	Develop and/or implement structure rehabilitation and repair programs.	X	X																																		
O&M	Develop a long-term sustainable and implementable Levee Vegetation Management Strategy	X	X							X			X		X			X			X							x								
O&M	Remove sediment from and investigate capacity of debris basins			X	X											X								x										x		
O&M	Conduct dam safety inspections and investigations							X											X										x								

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O&M	Develop funding mechanisms for O&M and new flood management improvements	X	X	X	X	X	X	X	X																													
O&M	Create shared strategic pooled money accounts that pre-fund avoidance/mitigation solutions for operation and maintenance impacts on current and future flood facilities.	X	X	X	X	X	X	X	X				X					X										x									
Flood Preparedness, Response, and Recovery	Increase local agency awareness of flood mitigation compliance and grant application assistance.	X	X	X	X	X	X	X	X																												x	
Flood Preparedness, Response, and Recovery	Establish a tsunami hazard zone with consistent requirements under local, State and federal agencies						X																														x	
Flood Preparedness, Response, and Recovery	Develop and implement criteria and processes for achieving a higher level of flood protection	X	X	X	X	X	X	X	X																												x	

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Flood Preparedness, Response, and Recovery	**Coordinate flood response planning and clarify roles and responsibilities related to flood preparedness and emergency response.**	X	X	X	X	X	X	X	X													X															x
Flood Preparedness, Response, and Recovery	**Create Emergency Action Plans to address dam failure**							X											X																			x
Flood Preparedness, Response, and Recovery	**Protect critical infrastructure corridors from flood waters.**	X	X	X	X	X	X	X	X																														x
Flood Preparedness, Response, and Recovery	**Purchase and pre-position flood fighting materials/tools in preparation for a flood event.**	X	X	X	X	X	X	X	X																														
Flood Preparedness, Response, and Recovery	**Participate in the StormReady and TsunamiReady Program**	X	X	X	X	X	X	X	X																														x

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Flood Preparedness, Response, and Recovery	Develop hazardous waste and materials management protocols to identify, contain and remediate potential water quality hazards within floodplains.	X	X	X	X	X	X	X	X	X			X				X	X			X							x	x							x
Flood Preparedness, Response, and Recovery	Establish standard flood warning systems and procedures.	X	X	X	X	X	X	X	X																												x
Flood Preparedness, Response, and Recovery	Improve stream gage network for forecasting purposes.	X	X	X	X	X	X	X		X								X																				x
Flood Preparedness, Response, and Recovery	Establish or improve instrumentation for early warning systems for flood facilities	X	X	X	X	X	X	X																														x
Flood Preparedness, Response, and Recovery	Integrate environmental compliance and mitigation into the flood fight.	X	X	X	X	X	X	X	X	X			X					X			X							x									

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Flood Preparedness, Response, and Recovery	**Improve communication and public awareness of emergency response procedures and terminology.**	X	X	X	X	X	X	X	X																										x
Flood Preparedness, Response, and Recovery	**Increase financial liquidity of local agencies during flood emergencies.**	X	X	X	X	X	X	X	X																										
Flood Preparedness, Response, and Recovery	**Improve evacuation planning.**	X	X	X	X	X	X	X	X																										x
Flood Preparedness, Response, and Recovery	**Develop post-flood recovery plans to improve the coordination and efficiency of post-flood assistance.**	X	X	X	X	X	X	X	X													X													x
Flood Preparedness, Response, and Recovery	**Streamline the post-flood permitting process for flood system repairs.**	X	X	X	X	X	X	X	X				X									X					x								

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Flood Preparedness, Response, and Recovery	**Encourage multi-jurisdictional and regional partnerships on flood planning and improve agency coordination on flood management activities, including operation and maintenance, repair, and restoration.**	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X		X	X					x	x			x				x	
Flood Preparedness, Response, and Recovery	**Clarify flood management responsibilities for local, regional, State, and federal agencies.**	X	X	X	X	X	X	X	X													X															
Policy and Regulations	**Encourage compatible land uses with flood management system and floodplain function.**	X	X	X	X	X	X	X	X	X	X		X		X			X			X		x			x		x	x	x	x	x	x	x	x	x	
Policy and Regulations	**Designate lands for dedicated flood flows**	X	X	X	X	X	X	X	X		X		X		X	X	X	X					x			x		x		x	x	x	x	x	x	x	
Policy and Regulations	**Develop local flood management plan updates**	X	X	X	X	X	X	X	X	X			X					X			X	X	x					x	x	x	x	x	x	x		x	x

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Policy and Regulations	**Provide information and data to assist local communities in planning and evaluating land use proposals on alluvial fan areas**				X						X											X	x			x				x	x	x	x	x			x
Policy and Regulations	**Managed retreat**					X	X											X												x				x				
Policy and Regulations	**Use Building Code amendments to reduce consequence of flooding.**	X	X	X	X	X	X	X	X																					x				x				
Permitting	**Develop regional and corridor conservation plans, or expand existing regional conservation plans (such as regional Habitat Conservation Plans and Natural Community Conservation Plans) to provide a more efficient and effective regulatory approval process for flood projects.**	X	X	X	X	X	X	X	X		X		X	X	X	X		X			X	X				x	x	x	x	x	x	x	x	x	x		
Permitting	**Develop regional advanced mitigation strategies and promote networks of both public and private mitigation banks to meet the needs of flood and other public infrastructure projects.**	X	X	X	X	X	X	X	X				X	X	X	X	X	X			X	X					x	x	x	x	x	x	x	x	x	x		

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Permitting	**Develop proactive integrated regulatory compliance strategies that streamlines permitting activities.**	X	X	X	X	X	X	X	X				X		X			X			X					x	x	x	x	x	x	x	x	x	x	
Permitting	**Increase understanding of environmental permits.**	X	X	X	X	X	X	X	X				X		X						X	X						x									
Permitting	**Corridor Management Strategy (CMS)**	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X			X					x	x	x	x	x	x	x	x	x	x	x	
Permitting	**Establish memoranda of understanding (MOUs) and/or management agreements between agencies to integrate the needs to be served by flood control systems.**	X	X	X	X	X	X	X	X	X			X					X			X	X	x	x	x			x	x	x	x	x	x	x	x	x	

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Finance and Revenue	Maximize funding for flood management projects by leveraging Federal funding.	X	X	X	X	X	X	X	X	X	X		X					X	X		X							x							
Finance and Revenue	Leverage funding from multiple projects to improve cost-effectiveness and efficiency of flood management projects.	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X							x							
Finance and Revenue	Establish a methodology for evaluating benefits and costs on a systemwide basis to support economic justification for projects in all community settings.	X	X	X	X	X	X	X	X																											